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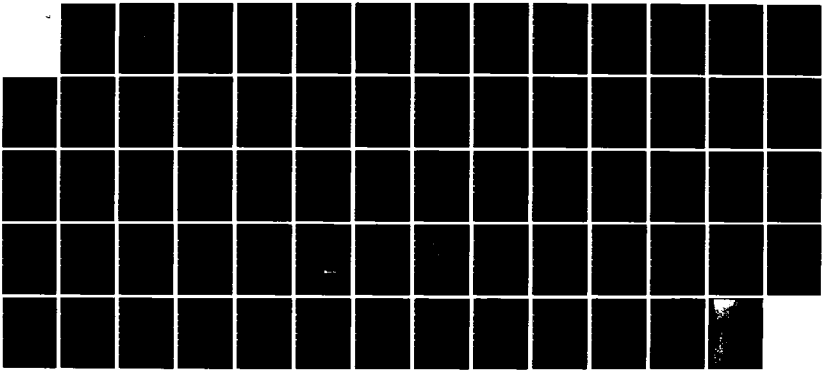

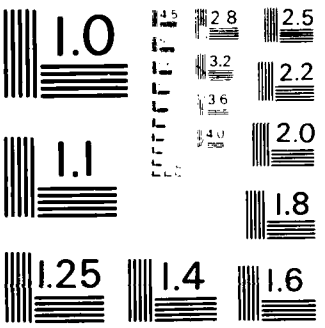

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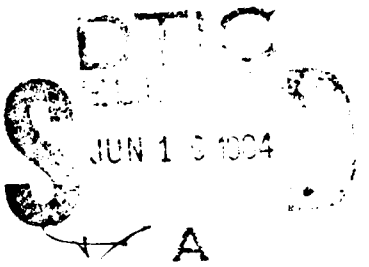

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Commanding Officer ..... CAPT M.A. Howard, USN
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June 1984
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BEHAVIORAL SCIENCES

BIOLOGICAL SCIENCES

COMPUTER SCIENCES

EARTH SCIENCE

EDUCATION

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ENVIRONMENTAL SCIENCES

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BEHAVIORAL SCIENCES

EYE-MOVEMENT AND COGNITIVE-PROCESS RESEARCH IN EUROPE: SOME EXAMPLES FROM SWITZERLAND

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Recent years have seen a marked increase in the use of eye-movement recording and analysis in the study of complex cognitive processes. The trend results both from improvements in the technology available for recording and analysis and from the advance of increasingly detailed and powerful information processing theories of cognitive activities in such areas as reading and problem solving. Much of the research has been conducted in the US. But there is also a strong surge in Europe; two books of collected works have recently appeared (Groner and Fraisse, 1982; Groner, Menz, Fisher, and Monty, 1983), another is in the offing (Gale and Johnson, forthcoming), and a directory (available from Groner and Menz, 1982) listed about 125 names of European scientists active in eye-movement research at the end of 1982.

Eye-movement data provide a unique adjunct to cognitive analyses based on measures of errors, reaction time or working time, and verbal reports by subjects. It must be assumed, of course, that eye movements have functional significance for cognitive operations in the task being studied, that peripheral vision is inconsequential for these operations, and that consecutive eye fixations beyond the first in each informative part of the display also have functional significance. Usually it is also assumed that eye fixations can be divided into scanning fixations associated with stimulus search and processing fixations associated with subsequent problem solution, and that cognitive processing occurs mainly during eye fixation rather than during eye movement. But these assumptions are subject to experimental checks and controls for any given task. Most importantly, best results usually derive from analyses of fixation durations and sequences that are driven by explicit theoretical models with strong behavioral predictions.

Sam is taller than Bill	Sam is taller than Jack
John is taller than Jack	Sid is taller than Jack
Fred is taller than Jack	Sid is taller than Bill
John is taller than Sam	Fred is taller than John
Jack is taller than Bill	Sam is taller than Sid

Figure 1. Example of the six-term series problem task as displayed to subjects.

The work of Rudolf and Marina Groner and their colleagues at the University of Bern, Switzerland, is exemplary of the best in this research. Some of their studies of cognitive processing in multiple-term series problems and in learning to read a new coded letter system are detailed here. But their program includes studies of motion perception, visual pursuit, and the effects of drugs on visual performance. Some new lines of work are also in the planning stage in the Groner laboratory.

Figure 1 shows the sort of multiple-term series problem often used in the study of reasoning during problem solving. The problem here is to determine who is tallest, second-tallest, shortest, and so on. It has long been thought that a form of hypothesis-testing behavior is a critical feature in this kind of reasoning--the subject assumes a tentative hypothesis such as "Sam is tallest"; proceeds to test this hypothesis against other terms in the display until it is found compatible with or falsified by the other information given; and, if the latter, then proceeds to the next hypothesis. But there are alternative models for such a process, and these have different substantive implications. One model, for example, called hypothesis testing with minimal memory load (HTM) by the Groners, assumes that eye fixations on the terms of the problem are completely random in testing a given hypothesis; after falsification, the next hypothesis again is tested by completely random search. HTM assumes no memory for previous hypotheses. Another, more efficient model, called HTG, assumes perfect memory for previous instances such that no premise will be fixated more than once during the testing of the same hypothesis; the memory for previously falsified hypotheses only goes back to the last falsified hypothesis, however. Other variants of such models are also possible. Each model can be

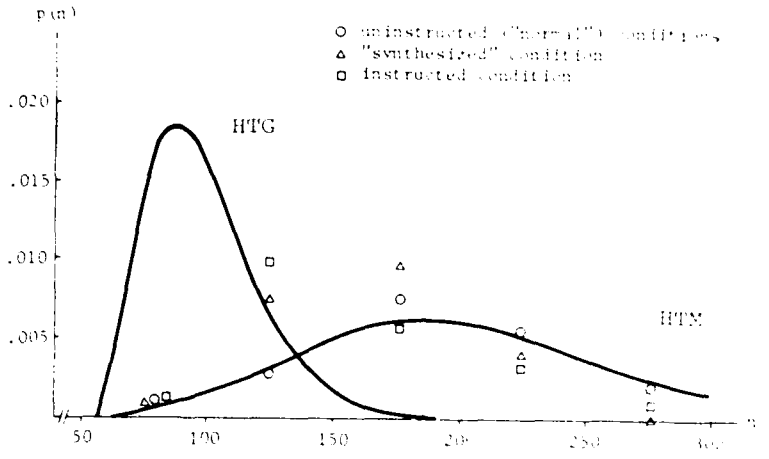

Figure 2. Predicted probability distributions for the HTM and HTG models of six-term series problem-solving (the solid curves) compared with eye fixation data for normal (circles), synthesized HTM (triangles), and instructed HTG (squares) experimental conditions. Data are for eye fixations spent by each subject from stimulus onset to complete solution, grouped in intervals of 50 fixations.

represented by a corresponding Markov chain that predicts different eye fixation paths and lengths.

In a series of experiments (Groner, 1978; Groner and Groner, 1982, 1983; Groner and Keller, 1978), such models were empirically tested using concept identification tasks as well as six-term series problems. Experimental conditions were also varied--in some, subjects were free to adopt any hypothesis-testing strategy, whereas in others an attempt was made to prompt subjects to use HTM or HTG.

Figure 2 summarizes some of the results. Under "normal" or unrestricted strategy conditions, subjects' eye-fixation patterns closely approximated the predicted curve derived from the HTM model. Under conditions designed to "synthesize" or force use of HTM, the curve obtained did not differ significantly from these. Under conditions designed to promote use of HTG through instruction, however, the obtained curve moved in the direction of the predicted HTG curve, but remained significantly different from both HTG and HTM. It thus appears that subjects cannot or do not use the more efficient strategy even when instructed to do so. HTM appears to be the most-used strategy, implying that subjects rely on the visual display as an external memory, to minimize internal memory load, and spend inexpensive eye fixations freely. This model also has succeeded in comparisons with some other models, using time and error data as well as eye fixations; various other implications about details of the processing system also are derivable from results under the different experimental conditions so far examined. The results thus converge on the validity of HTM, suggesting that it should be tested much more widely in other tasks.

In the reading-skill-acquisition experiments (Menz and Groner, 1981, 1982, and forthcoming), a figural alphabet code and its use in reading text is learned. Figure 3 shows an example slide. Here the experimental arrangements allow the quantification of progressive left-right eye movements, regressive right-left movements, decoding jumps between the letter code and text, the duration of these various kinds of fixations, and the correspondence between these variables and vocalizations during reading. The data can be analyzed at several levels. The time course of all these variables can also be examined across stages in learning.

The general hypothesis underlying this work is that a hierarchy of processing units is built up during learning and, thus, there is information organization at different levels. It is the organization of information processing that becomes more efficient over the course of learning. There is also a distinction in this view between "width of processing," defined as saccade size (i.e., the distance traversed by single progressive eye movements) and "depth of processing," defined by fixation and

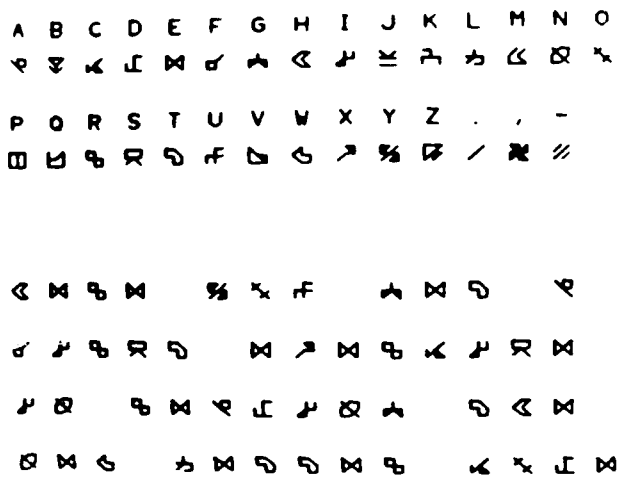

Figure 3. Example of one frame of the letter-code reading acquisition task as displayed to subjects. The upper part shows the code list; the lower part four lines of text.

pause durations. The experiments conducted so far have examined various measurement issues in this context and have begun the study of this hypothesis. Several semantic and syntactic variables in the text have also been studied.

The results to date suggest marked individual differences in information-processing strategies and in the time course of acquisition for different learners. Thus, all data analysis and modeling must clearly be conducted separately for individual subjects. Differences can be seen in decreases over trials in reading time, number of fixations, and fixation duration, and in increases over trials in regression sizes. On average, width of processing does not seem to expand over learning in this task, while depth of processing decreases slightly with learning.

The detail with which these sorts of data are currently being analyzed can be illustrated by Figure 4, which shows one aspect of synchronicity between vocalizations and progressive eye movements. The curves are frequency distributions of time differences between onset of vocalization and the beginning of eye progression, summed over a range of ±5 seconds. The upper curve in each graph shows the frequencies of all pairs within the given interval; the lower curve in each graph gives the frequencies for the last progression before a vocalization (left side of graph) or the first progression after a vocalization (right side of graph). The peaks at +0.2 second indicate that eye progressions tend to follow vocalizations by this amount of time, on average. It can be seen (by comparing the upper and lower graphs, representing early and late learning stages, respectively) that learning results in decreased variability--the timing of ocular and vocal reactions becomes more regular and perhaps more automatic. Also, comparing the upper curves across the two graphs, it is seen that the frequencies on the left side are significantly lower in early learning relative to later learning. This is interpreted as indicating a tendency of the learner to suppress eye progression prior to vocalization--a tendency which disappears with continued learning.

The potential of this approach for studying the details of information processing models of reading and reasoning, and the necessary variation across individuals and learning experiences that must be built into them, seems uniquely powerful. In recent years, largely through a variety of research projects sponsored by the Office of Naval Research, US cognitive psychologists have developed new models of reading and of reasoning, studied individual differences and learning and strategy training in the context of these models, and used eye-movement data as an aid in this process. But these separate developments have not yet been brought together for comparison and integration within a single programmatic effort. The Groners' laboratory in Bern is one place now poised for this crucial next step.

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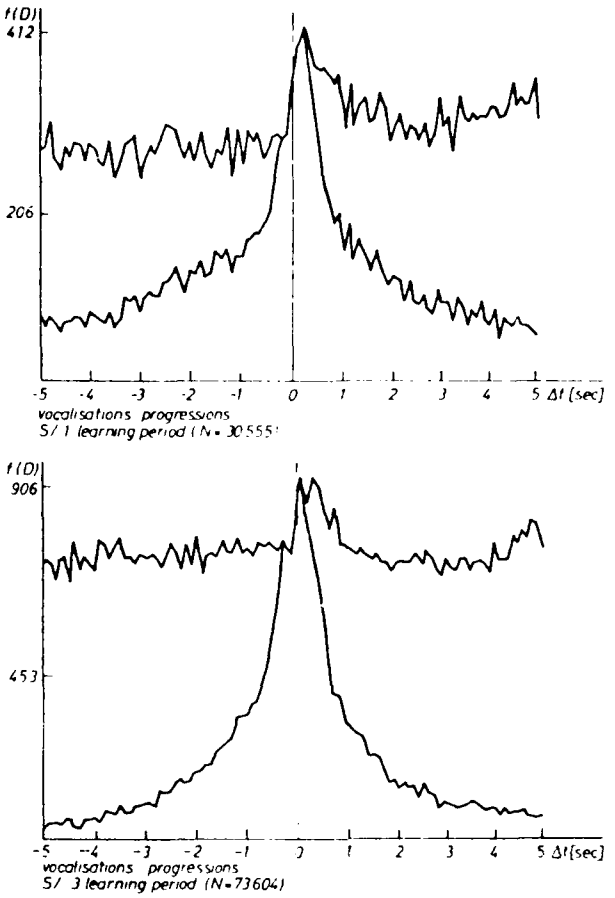

Figure 4. Graphs of synchronicity between vocalizations and eye progressions during reading. Upper and lower graphs show first third and third third of the learning period, respectively. Upper curves in each graph show frequency distributions of time distances for all pairs of vocalizations and eye progressions; lower curves in each graph show distributions of distances for the next eye progression before or after a vocalization.

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THE NEO-PIAGETIAN EXPLOSION

By [illegible]

Jean Piaget was the founder and director of Centre International d'Epistémologie Génétique, Université de Genève. He was a monumental intellect in the epistomology, history, and philosophy of science, and many would say also in the science of psychology, as well as in the psychology of science. Piaget might say that he only used psychology as one of several tools to help understand the nature and growth of human knowledge and intelligence in general--knowledge formation in the individual and in the collective was the central, and primarily epistomological, concern. But he certainly came, in his later years at least, to value psychology for itself and to acknowledge his own contributions to it. In one of his last papers, Piaget (1979, p. 1) speaks of "our science" and its reciprocities (with biology, the logico-mathematical and cybernetic disciplines, the social sciences of linguistics, economics, and sociology, and even with physics), emphasizing that: "Psychology occupies a key position in the family of sciences in that it depends upon each of the others, to different degrees, and in turn it illuminates them all in distinct ways." This brief lecture should give valuable pause to anyone who thinks of psychology as merely a derivative, subordinate, or questionable extension of physical and biological science.

Piaget's stupendous contributions to developmental psychology stretch in a continuous stream from the 1930s through the 1970s. In the US, however, the importance of his work was recognized quite late (see, e.g., Berlyne, 1965; Flavell, 1963; Hunt, 1961) and the limits of Piagetian theory still much later (see, e.g., Flavell, 1977). Despite US tardiness and what it signifies as an example of the psychology of transnational, translanguage science, it was striking to learn recently that Piaget's fellow citizens in German-speaking Switzerland had had to discover Piagetian theory via the Americans!

Piaget's theory is a strict, structuralist view of the course of cognitive development as an invariant series of stages for all human beings, unmodifiable by any sort of environmental engineering. It is quite obviously a genetic epistomology; it is also a rich description of human mental growth. But despite the depth and breadth of research that emanated from his center in Geneva over the years, and from the many investigators following the Genevan line elsewhere in the world, the psychological studies always seemed to bear the master's stamp; many important questions and conflicts with other theories seemed not to be adequately addressed. In recent years, however, and particularly following Piaget's death, there has been an explosion of studies from Geneva and elsewhere showing a variety of new and different concerns as well as several adaptations to the influences of other kinds of psychological theory.

A substantial sample of this new work has now been surveyed by Bullinger and Chatillon (forthcoming) in a chapter ranging across research in the cognitive psychology of knowledge and problem solving, infant development, psycholinguistics, cross-cultural psychology, ethology, and applications in clinical, social, and educational psychology. In the psychology and educational research departments of the Universities of Geneva, Neuchatêl, and Fribourg, Switzerland, and also in France and Canada, one easily finds other examples to add to the Bullinger-Chatillon survey. To this reader, a major confluence of US and Neo-Piagetian cognitive psychology seems to be at hand in several of these areas of research. In most cases, the shift in Neo-Piagetian emphasis seems to be from strict structuralism to a more functional concern with the relation of mental representation, thought, and action. This article gives only a few examples to show the implications for research on problem solving, adult intelligence, and individual differences.

The functional-procedural study of problem solving within the Piagetian framework began with Inhelder's (1978) interest in strategies developed by subjects when confronted with problems to solve, and in the mechanisms of elaboration and change in strategy by subjects at different ages. Piaget (1976) had distinguished three kinds of strategies or "schemes" to define the structure of an action: presentative schemes that represent the stable characteristics of objects or concepts; procedural schemes that are action sequences designed to attain particular and limited short-duration goals; and operatory schemes that are syntheses of the previous two to provide generalized procedures, such as seriation or classification. The coordination of presentative and operatory schemes provides the structures or systems by which a person *understands* the world of physical realities and relations, and causality; this was Piaget's persistent focus. But Inhelder became especially interested in

the other coordinated system of procedural and operatory schemes by which a person operates in the world of various and changing problem situations.

Inhelder and her colleagues added a further distinction between a strategy composed of actions sequenced in a productive order (where the sequence is built up and carried out by degrees to achieve a goal), and those composed of actions sequenced in a precursive order as a function of goal characteristics (where the sequence might be determined by the subject in the reverse order from that in which it is carried out, based on analysis of the goal). The assembly of strategies might be governed by either order or by a coordination of the two. It was recognized also that ineffective procedures are often replaced by more effective procedures as subjects progress through an experiment; they discover and invent procedures as they go along, and seem to draw from a reservoir of presentative schemes in improving their procedural schemes. The improvement is also often apparently accomplished by successive adjustments in strategy to reach a final solution procedure. A number of experiments seemed to bear out the importance of these distinctions. They also show that the coordination of the two orders can be cyclical--alternating between a precursive and productive sequence in the same problem. A precursive order seems analogous to what is usually called top-down processing in US research--a directing idea or overall concept controls the sequence of actions toward the goal. A productive order, on the other hand, implies bottom-up processing, in which successive changes in the directing idea occur as a result of actions taken and the assessment of intermediate results.

This work has in turn led to similar studies of adult cognitive functioning. Chatillon (1980), for example, found that the initial representation of the problem strongly influenced performance; individuals who were able to imagine the sequence of procedural steps most precisely in a top-down fashion were most successful in problem solving. In a study of executive processes in spatial problem solving, Pailhous (forthcoming) suggests further that the best-performing individuals are able to organize their relevant knowledge as a set of instruments and to generate a system for specific representation and processing using these. The power of the generated system depends on the size of the class of knowledge instruments and the efficiency of their organization with respect to the goal. Transfer of these instruments to new situations has also been studied by Carreyach (1979), who suggests that adult subjects construct a knowledge of a new situation by using their instruments of knowledge in the same ontogenetic order in which they were acquired. It is acknowledged, however, that the adult may only appear to use an ontogenetic order; clearly, also, the knowledge instruments used need not be the same as they were when acquired years before. To analyze the constructive sequences of actions during problem solving and changes in these sequences, these and other investigators have been experimenting with, for example, observations of facial expressions, incipient gestures and verbalizations, eye fixations, hesitations, and modification of work rhythms--in addition to conventional performance measures.

It remains to be seen how closely this empirical work corresponds in its implications to that produced by US research in cognitive information processing. It is already clear, however, that the theoretical correspondences are close both to US theory and to some of the theories of action formation coming from Russian research (Galpérine, 1966).

The emphasis on operatory schemes, strategies, organizations of these, and adjustments in them during problem solving comes close also to US research on individual differences in aptitude for problem solving. Neo-Piagetian research has now entered this arena as well, after decades of delay due to Piaget's insistence on establishing general structures first (and only). Longeot (1978), for example, has developed measures to test for hierarchial structure in developmental differences. While confirming the hierarchical aspect of Piagetian theory in part, the results also showed marked differences in task difficulty *among* situations that would have been presumed to require the same mode of reasoning. The work also identifies an intermediate state of reasoning not predicted by prior theory. Lautrey (1980) has further shown that such hierarchical analyses are extremely sensitive to sample variations and that marked intra-individual differences in operatory level can be observed with shifts in experimental situation. De Ribaupierre and Rieben (1983) have now gone on to mount a large study of inter- and intra-individual variability using a battery of Piagetian tasks. Although the analysis of these data is not yet complete, it is clear that the range of both kinds of variability is

sufficiently great to call into question any simple interpretation of stage structure theory. Marked individual differences in procedural activity within stage across tasks, as well as in the Piagetian stage eventually reached by adults, opens a whole new realm for theory and research for the Neo-Piagetians (see, e.g., De Ribaupierre, 1983; De Ribaupierre and Pascual-Leone, 1979).

In turn, the work has led to research in educational and industrial settings in which both the Piagetian structural view and the new emphasis on procedures is used to analyze sources of difficulty in instructional tasks and in behavior in work situations. It is clear, for example, that there are many sources of difficulty in such tasks that produce individual differences and situational differences that do not simply reflect differences in the mode or stage of reasoning required. The cognitive activity of workers in complex jobs usually also involves multiple goals. Analyses of these issues has provoked complex questions for further theoretical study.

There is no meaningful summary at this early date. But to this reader one conclusion seems clear: the Neo-Piagetian agenda has blown wide open--with the explosion comes many opportunities for coordination between US and Genevan theory and research.

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3/26/84

BIOLOGICAL SCIENCES

EXTREMELY LOW FREQUENCY MAGNETIC FIELDS AFFECT CHICK EMBRYOS

by Thomas J. Bonzell. Dr. Bonzell is the Liaison Scientist for Biological

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Two years ago, Spanish researchers found that extremely weak, pulsed magnetic fields (repetition rate of 100 Hz and 1.2 μT) caused malformations in developing chick embryos. That report (Delgado et al., 1982) at once stunned and perplexed the bioelectromagnetics research community. This type of biological response had been seen with low-level electric fields but never before with magnetic fields at such low levels--much less than the earth's.

What Dr. Delgado and his team at the Departamento de Investigacion, Centro 'Ramon y Cajal,' Madrid, Spain, found was that a 48-hour exposure of fertilized eggs from white Leghorn hens to the weak magnetic fields resulted in consistent and significant inhibition of embryogenesis as revealed by gross morphological and histological analysis. Auditory pit, forequt, brain vesicles, neural tube, heart, vessels, and somites were not developed. They postulated that the alterations in growth may be due in part to disruption in production and disturbances in the structure of glycosaminoglycans (GAGs), which are essential elements in differentiating cellular activity and in cell migration.

It was immediately evident that such biological sensitivity to extremely low-frequency and low-intensity magnetic fields could have far-reaching implications for a number of military and industrial operations. Several individuals began trying to obtain enough information to replicate this study in an effort to substantiate the findings. However, when attempts were made using either frog or hen eggs, only negative results were found, and all exposed eggs were apparently no different from the controls. These findings began to cast doubt on the reported results of the Spanish group. Thus I visited the laboratory in Madrid to find out exactly why follow-up studies have been so uniformly negative in the face of continuing reports of positive effects from their laboratory. By the time of my trip, Delgado and his coworkers had published another paper (Ubeda et al., 1983) in which they examined the importance of waveform in determining the biological response of the developing embryo.

In the initial Madrid study, eggs were placed in an incubator at 39°C and 55-percent relative humidity for 48 hours. The eggs being exposed to the magnetic fields were placed in pairs on a wooden holder inside a 110-mm long, 55-mm diameter cylindrical coil wound with 0.1-mm enameled copper wire. Control eggs were placed in the same incubator 200-mm away from the coils. The coils were energized by a Grass S88 stimulator using rectangular waves of 0.5-ms pulse duration at repetition rates of 10, 100, and 1000 Hz with magnetic field intensities created in the coils at each frequency of 0.12, 1.2, and 12 μT. The magnetic field intensity was that measured along the center axis of the coils. The eggs were placed such that their long axis was parallel to the long axis of the cylindrical coil, and the egg holders were such that the embryo, which in the early stage of development is at the top of the yolk sac, was lying just at the center line of the coil.

Two similar experiments (a total of six eggs) were conducted simultaneously, with two coils being activated with the same Grass stimulator, coupled by a series capacitor. The electrical currents were continuously monitored with an oscilloscope.

After 48 hours of incubation, and exposure, the eggs were expected to have reached a well-established stage of development that could be quantified by a tried and proven scale. At this point, the eggs were opened for examination. After fixation, the embryos were observed with a stereomicroscope. The samples were coded so that the person scoring was unaware of which were exposed and which were control embryos.

In the histological studies, the embryos were dehydrated with alcohol and embedded in paraffin. Seven-micron-thick sections were cut transverse to the main axis of the embryo, mounted, and stained. The slides, again coded, were examined microscopically. The microscopic study looked for development and organization of: (1) the cephalic nervous system, (2) the truncal nervous system, (3) the heart, (4) vascularization, and (5) somites. Each embryo was classified as normal (N) or abnormal (A) in each of the five morphological features. The results are shown in Tables 1 and 2. It should be pointed out that of the 26 control eggs, only four were abnormal: one in the 10 Hz/1.2 μT series was abnormal in all morphological features; one in the 1000 Hz/0.12 μT series had an abnormal cephalic nervous system and an improper number

Table 1

Malformations in Controls and in Chick Embryos Exposed to Extremely Low-Frequency Magnetic Fields (ELMFs)

	Controls (n = 26)*			Exposed to ELMF (n = 42)		
Organs	Malformed embryos	%	S.E.	Malformed embryos	%	S.E.
Cephalic nervous system	3	11.5	6.4	33	78.5	6.3
Truncal nervous system	2	7.7	5.3	26	61.9	7.5
Heart	2	7.7	5.3	23	54.8	7.7
Vessels	3	11.5	6.4	28	66.7	7.3
Somites	3	11.5	6.4	24	57.1	7.6

*n = total number of samples; S.E. = standard error.

of somites; another from this same series was abnormal only in vascularization and number of somites. The fourth abnormal control belonged to the 1000 Hz/12 μT series and was abnormal in all morphological features.

It was astounding to observe that 33 of the 42 embryos (78.5 percent) exposed to the magnetic fields had detectable abnormalities in their early stages of development. It was clear, as Table 1 indicates, that the highest frequency of abnormality was in the cephalic nervous system. The heart was the most hardy system, although the changes seen were highly significant.

It appeared in this set of experiments that there was a "window" for the effect of the magnetic fields, the intermediate conditions of 100 Hz and 1.2 μT being more effective in production of all abnormalities than either the higher or lower frequencies or higher or lower intensities.

Follow-up studies by Delgado and his team have shown even more astonishing aspects of this very sensitive magnetic field effect. First, placement of the egg and its orientation appears to be very critical. Second, the orientation of the egg with respect to the earth's magnetic field may be important. Third, the wave form of the pulsed magnetic field may be critical, though this has been challenged and suggestions made that the sensitive variable is the rise time of the pulse.

The egg-placement details are apparently very important and were not mentioned in the original paper in 1982. This appears to be one of the key reasons why efforts to duplicate the Delgado experiments have been unsuccessful. In fact, Delgado and his coworkers have made another observation that further illustrates the critical nature of the orientation of the embryo with respect to the magnetic field.

When the magnetic-field-treated eggs were opened at the end of the 48-hour exposure/incubation period, it was observed that some of the embryos had changed their position in the egg to lie approximately perpendicular to the long axis. Surprisingly, all these embryos were normal, whereas almost all that did not reorient themselves, and thus remained parallel to the direction of the magnetic field, were abnormal. This raises the question of whether the reorientation was a behavioral mechanism that allowed a smaller cross section of the embryo to be presented to the field, thus reducing the amount of absorbed energy. None of the control embryos changed their position in the egg during the 48-hour incubation period.

To rule out possible differences due to the ambient earth's magnetic field, all eggs were placed so that the long axis was in an east-west direction. It is not known exactly how much shielding of the earth's magnetic field was provided by the incubators.

A number of past studies have reported that waveform is critical in eliciting biological effects using either pure electric fields or capacitively coupled electric and/or magnetic fields. The most striking of these have been studies that show osteogenesis to be highly dependent upon the wave form of the applied field (Pilla, 1974; Bassett, 1982). However, the importance of the waveform is being questioned quite closely, and more and more studies are being reported that tend to show that the shape of the applied wave is not nearly as important as are pulse characteristics such as frequency and rise time. There was considerable discussion of this point at the First

Table 2

Gross Morphological Evaluation of Chick Embryos Exposed to ELMFs of the Indicated Frequencies and Intensities

Frequency (Hz) →	10			100			1000		
Intensity (μT) →	0.12	1.2	12	0.12	1.2	12	0.12	1.2	12
Cephalic nervous system	N	A	A	A	A	A	A	A	A
	N	A	N	A	A	A	N	A	A
	A	N	N	N	A	A	A	A	A
		A	N	N	A	A		A	A
			A		A	A			
					A	A			
						A			
						A			
						A			
Truncal nervous system	N	A	N	A	A	A	A	A	A
	N	N	N	A	A	N	A	A	A
	A	N	N	N	A	A	A	A	N
		N	N	N	A	A		A	N
			A		A	N			
					A	N			
						A			
						A			
Heart	N	A	N	N	A	A	A	A	A
	N	N	N	A	A	N	N	A	A
	N	N	N	N	A	A	A	A	N
		N	N	N	A	A		A	A
			N		A	N			
					A	N			
						A			
						A			
Vessels	N	A	A	A	A	A	A	A	A
	N	N	N	A	A	N	N	A	A
	N	N	N	A	A	A	A	A	A
		N	N	A	A	A		A	A
			A		A	N			
					A	N			
						A			
						N			
						A			
Somites	N	N	N	A	A	A	A	A	A
	N	N	N	A	A	N	A	A	A
	N	N	N	N	A	A	A	A	N
		N	N	N	A	A		A	A
			N		A	N			
					A	N			
						A			
						A			
						A			
Totals	12 embryos			19 embryos			11 embryos		

International Meeting on Biological Effects and Therapeutic Applications of ELF Electromagnetic Fields (Venice, Italy, 23 through 25 February).

In their most recent study, Delgado and coworkers (Ubeda et al., 1983) exposed a total of 659 (295 experimental and 364 control) freshly fertilized hen eggs at a repetition rate of 100 Hz and pulse width of 500 μs. They used four different pulse shapes, as shown in Figure 1. The magnetic field intensity varied between 0.4 and 104 μT and the rise time of the pulses was 42 μs.

There can only be speculation about whether these abnormalities result from metabolic changes or whether they are due to direct action of the field on

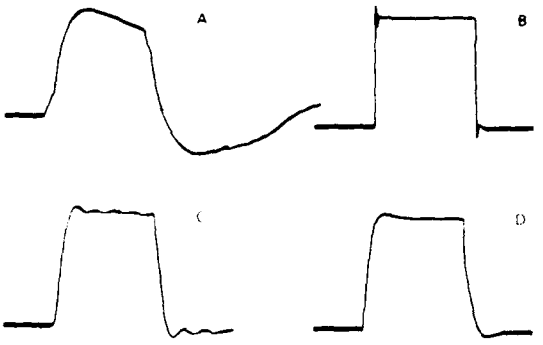

Figure 1. Pulse signals: in all experiments, pulse duration (500 μs) and repetition rate (100 Hz) were constant. Four different pulse shapes were used: (A) rise time 100 μs; (B) rise time 7 μs; (C) rise time 42 μs; (D) rise time 42 μs.

cell membranes, on glycosaminoglycan components, or on both. It is evident that the developing chick embryo is very sensitive to extremely low frequency, extremely weak magnetic fields. Discussion at the Venice meeting and evidence in a recent paper (Liboff, 1984) suggests that the critical parameter may be the instantaneous rate of change of the energy input, and that the actual frequency or wave form may have very little impact on biological responses of these weak fields. There is general agreement that much is still unknown and a lot of work remains.

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3/20/84

COMPUTER SCIENCES

COMPUTER SCIENCE AT THE FREE UNIVERSITY OF BRUSSELS

[redacted]

At the Free University of Brussels Informatics Laboratory research centers three main areas of activity: parallel systems, probability and computer science, and semantic problems. Emphasis in parallel computing systems is on solving the deadlock problem. In probability and computer science a major part of the work is on stochastic models for response times in processor-sharing computer models. The work in semantics has concentrated on a new command language and on error-recovery procedures.

Parallel Operations

An important study concerned avoidance of deadlock in a parallel system. The deadlock-avoidance problem may be defined as the determination--from some a priori information about the processes, resources, and operating system--of what situations may be realized without endangering the smooth running of the system. When each process specifies its future needs by a flow chart of need-defined steps, a global approach to the phenomenon and its interpretation as a game between the operating system and the process allows formalization of risk and safety concepts. The bipartite graph representation of this game may then be used to construct explicitly the set of safe states and to study their properties.

In the past, two types of models have been considered:

1. The maximum claim model in which each process only specifies a bound on its future needs for simultaneous resources. In this case, it is possible to show that a situation is safe if and only if there exists an admissible ordering of the process that can be checked by an algorithm--e.g., the banker's algorithm.

2. The task-step model, in which each process specifies the sequence of its needs by a linear history, a succession of need-defined tasks to be realized. In this case, a situation is safe

[illegible] if there exists an admissible ordering of the various steps that can be checked by Habermann's algorithms (Habermann, 1969).

At Brussels a global approach has been taken which tries to follow as closely as possible the true deadlock phenomenon. Three types of states were considered: (1) the working states (S_i^k) representing the process P_i executing its kth steps ($k > 0$); (2) the transit states (S_i^{*k}) representing the process P_i having terminated its $(k-1)$th step and asking the operating system for permission to enter its kth step; and (3) the terminated state (f_i) representing the process P_i when it has terminated its task.

The operating system may interpret the evaluation of the system as a game between itself and the processes, the winning condition being that all the processes have been run to completion. The states of the system are thus characterized by the states of the various processes and the identity of the player who has the move.

The moves of the players depend on the operating system philosophy. It may detect at most one, at least one, or any number of new requests for transition and grant at most one or any number of requests in one loop. It can be shown that the corresponding games are equivalent for the deadlock avoidance problem.

Methods of constructing safe states have been worked out at Brussels. The analysis of the deadlock phenomenon and its game interpretation permits defining safety in a satisfactory and useful manner. This definition leads directly to a simple, progressive construction of the set of unsafe states, which may be used to study the properties of the safe states (Devillers, 1977).

Probability and Computer Science

Earlier work on stochastic models for response times in processor-sharing computer models has been generalized and extended. In the [illegible]und-robin method of central computer-capacity allocation with j jobs or programs at the execution stage, each receives service attention one-jth of a time unit per time unit. If the chance that any single job, processed alone, finishes between time t and $t+k$ is $\mu h+0(h)$, then the chance that a particular job out of $j-1$ others will finish between time t and $t+h$ is $\mu \frac{h}{j} + 0(h)$ as $h \to 0$. This permits short jobs access to processing even if they arrive after, and queue with, longer jobs.

A recent paper by D. Mitra (1981) analyzed response time under the assump- [illegible] system [illegible] puter in which [illegible] computer [illegible] served as [illegible] Under the [illegible] in the previous [illegible] terizes the [illegible] time and determines the [illegible] ance under various conditions.

Researchers at Brussels [illegible] the idea of processor sharing in an arbitrary birth and death process environment, allowing quite general terminal-computer interactions to be represented. Response-time characteristics were computed under the assumption that processor-sharing service rates are processor-state dependent in a quite general way. This permits approximate representation of overhead penalties and of job scheduling. Researchers studied the accumulated processing work, $W(T)$, actually performed in that job by elapsed time T (T at least equals the required processing time) following job introduction. One conclusion was that the accumulated work accomplished by fixed time T on a "long" job is approximately normally distributed. From this it can be concluded that the response time for a "long" job is also approximately normally distributed (Gaver, 1983)

Semantic Problems

A new command language was introduced for bibliographic database searches. Although the language syntax contains 311 rules to describe the grammar, it is easier to use for analysis and is more realistic than earlier versions. Many meaningless commands are syntactically avoided. It can be adapted to any bibliographic database, and it provides extensive and useful facilities (Vander Auwera, 1982)

Another study deals with syntactic analysis and recovery from errors. When a syntactic analysis system encounters an error of syntax, it must be able to examine the text submitted without losing lexical elements and without risk of recycling.

Two systems of error recovery were developed for bottom-up analysis (Bernard, 1982).

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8/8/84

DATA-STRUCTURE-ARCHITECTURE COMPUTER AT THE TECHNICAL UNIVERSITY OF BERLIN

by J.F. Blackburn.

The ACM Turing Award, Lecture of 1978, given by John Backus of IBM, San Jose, described the shortcomings of conventional Von Neumann computer architectures. Before the central processing unit (CPU) of a conventional computer can process a data item, it has to fetch it from memory by an instruction, which itself must first be fetched from memory after an address has been computed. For each operation that changes the state of a single datum, the CPU must fetch and execute several instructions to establish the order in which single-memory words are to be fetched and to instruct the hardware accordingly. This "overhead" is typically about three times the number of state-transforming operations of a program.

Backus proposed the functional programming style as a way out of the conceptual bottleneck that keeps programmers thinking of a word at a time instead of larger conceptual units. This caused an upsurge of interest in functional programming and was a big factor in the development of the principle of data-flow architecture as the underlying computer architecture for functional programming (*ESN* 36-12:323 [1982]).

Wolfgang Giloi (Technical University of Berlin) maintains that functional programming mitigates the intellectual bottleneck but not the physical one, because the data-flow machines proposed so far consist of microprocessors using conventional architecture but operating in parallel. Hence, he says, such a machine will consist of a number of Von Neumann bottlenecks operating in parallel. To resolve the physical bottleneck problem, appropriate data-structure objects should exist at the hardware level as objects of machine data-structure types that are recognized and manipulated by the machine. This approach allows the computer to deal efficiently with the parallelism inherent in data-structure objects.

A multi-microcomputer system called STARLET (structured, typed, array-based representation) is being built at the Technical University of Berlin. STARLET has a data-structure architecture.

Data-structure architectures are computer systems that manipulate at the hardware level arbitrarily complex data-structure objects as entities. The entire data structure is referenced by a symbolic name. Substructures or single data items are accessed by executing access functions. In this architecture the conceptual bottleneck is avoided because the computer supports procedural or functional program mini-languages that allow changing arbitrarily complex data-structure objects by a single complex operation invoked by a single instruction. There is no physical bottleneck since data items are moved to and from memory by an address stream computed by the access processor at high speed. The inherent known parallelism of data-structure objects is exploited for parallel processing in the single-instruction, multiple-data (SIMD) mode.

In contrast to machines that have only one data-structure type, the vector, STARLET incorporates the concept of data abstraction at the hardware level. Since the data items of a complex object can be accessed only through application of the functions of the data type to which the object belongs, it is solely the function behavior that determines the structure of the object. The data structures at the machine-language level may differ from the structure of their internal representation. The latter is chosen so that its value can be easily accessed and processed by hardware.

Giloi defines an abstract data type as a class of data objects of some sort and a collection of functions which can act on the objects of the class. The STARLET computer uses the principle that

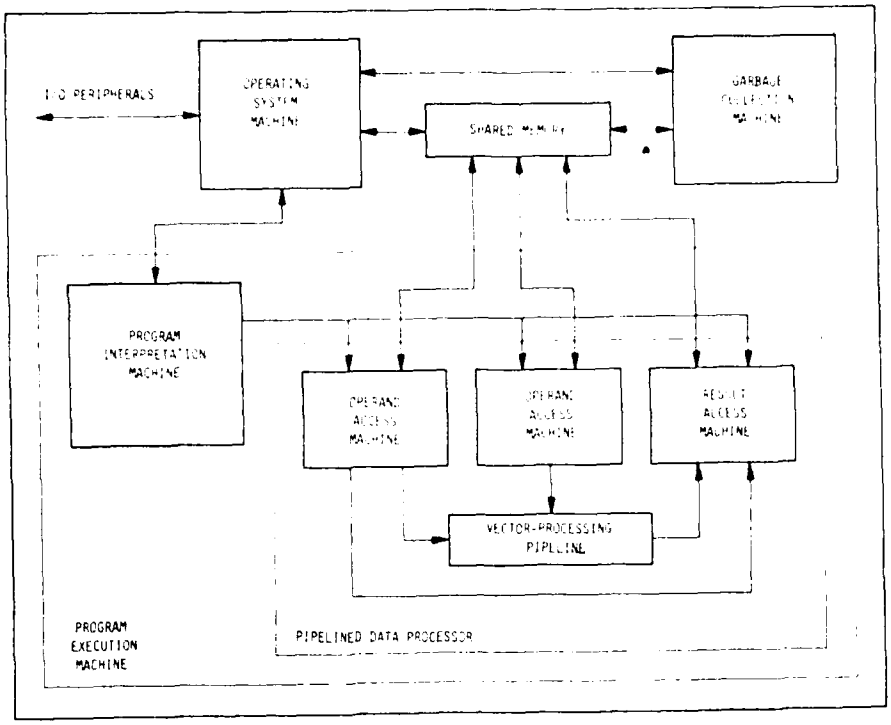

Figure 1. The STARLET system.

the nature of the objects is completely determined by the function behavior to allow the incorporation of arbitrarily defined machine-data types with structured-data types. The construction of application-oriented data structure types takes place in the form of arbitrary, user-defined abstract data types, while the set of machine-data types is restricted to types that provide most appropriate and sufficiently general representations of the objects and functions of the user-defined types. The objects of user-defined data types are not accessible from outside the type.

The programming method supported by STARLET may be abstract data-type based, imperative procedural programming (e.g., ADA programs in which the package concept is used), or a functional programming style (e.g., Backus' ATS).

Data-flow machines perform a data-dependence analysis for each operation to determine whether the operation is executable. This results in considerable overhead. In contrast, data-structure architectures use the inherent parallelism in data-structure objects, without the need for data-dependence analysis.

STARLET is realized as a multicomputer system exhibiting a sophisticated scheme of hierarchical function distribution among the various machines in the system. Figure 1 is a logical block diagram of the STARLET computer. It is a strongly coupled system in which an operating system machine, a garbage collection machine, a program interpretation machine, three data-access machines, and a data processor communicate through a high-speed shared memory (access <100 ns). The operating machine is a multicomputer system featuring three or more computers of the Motorola MC68000 microprocessor type. The other machines are also MC68000's--except for the data processor, which is a customized, high-speed pipeline processor for arithmetic operations, searching, and sorting. High performance will come from: (1) use of very fast components, (2) SIMD architecture, (3) parallel processing in the pipeline processor, and (4) the parallel operation of the various machines of the multicomputer system.

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3/2/84

EXPERT SYSTEMS AT KAISERSLAUTERN UNIVERSITY

by J.F. Blackburn

Expert systems are a major concern of the research on artificial intelligence at Kaiserslautern University, Federal Republic of Germany. According to Peter Raulefs of Kaiserslautern University, an expert system should: (1) mechanize the activities of human experts, and (2) represent fields of science in a manner to facilitate mechanical manipulation.

Expert systems--special types of knowledge-based systems--have gained significant economic and scientific importance in recent years because of their performance, the increasing demand for expert consultants, and the potential cost reduction resulting from mechanization of expertise. An expert system may mechanize the activities of a human expert in varying degrees. Total mechanization of a human expert by such a system requires mechanizing expertise, consisting of knowledge and skills, and consulting competence. In most cases this can be done only partially.

In order for an expert system to have consulting competence it must:

- Understand the client's queries, transform them into internal representation, and recognize approaches to apply its own expertise.
- Solve the client's problems where its own expertise applies.
- Construct an answer which explains the solution to the client so that the client can understand and apply it.
- Explain to the client the reasoning resulting in the answer so that the client may judge the reliability of the solution given by the expert system.
- Help the client in applying and integrating the solution.

Raulefs says there are three requirements to consider when designing an expert system:

1. Expert systems are intended to manipulate vast quantities of poorly structured knowledge and skills. Hence, expert systems require a representation of knowledge and skills which supports (a) rapid detection of expertise for situations in which the expertise is immediately applicable to achieving goals, and (b) the acquisition of large amounts of new knowledge.

2. Expert systems should incorporate all domain-specific reasoning mechanisms and problem-solving skills belonging to the respective area of expertise.

3. Expert systems should have capabilities for comprehending clients' queries and for constructing, explaining, and applying solutions.

Abstraction is the most effective method for representing large amounts of knowledge. The two main techniques are schematization and axiomatization. A schema or pattern is a syntactic object to which applying a substitution results in an instance of the pattern. Thus a pattern is an abstraction of its extension. An area of knowledge is axiomatized by a formal system consisting of axioms, deduction rules, and meta-rules--i.e., rules specifying how deduction rules may be applied, or altered and applied to achieve deductions in a goal-oriented way.

Pattern-directed inference systems integrate schematization and axiomatization, and form the core of most expert systems. Production systems are the most common of pattern-directed inference systems. A production system consists of:

- A database, which is a system of syntactically uniform encodings of chunks of knowledge.
- A production base, which is a system of production rules consisting of a pair < situation > → < action >, where < situation > is a pattern, and the effect of applying a production rule is determined by the interpreter of the production system.
- An interpreter, which consists of: (1) a pattern matcher matching data of the database to < situation > patterns of productions in the production base; (2) an executor for executing < actions >, possibly changing data and production base; and (3) a control to select production rules to be considered by the pattern matcher and executor.

Further details about structure of the database, control, selection mechanisms, and conflict resolution techniques are given by Raulef (1983).

The work on expert systems at Kaiserslautern is in automatic programming; medical and technical applications; and planning, configuration, and construction of computer systems.

In the automatic programming effort a LISP language program is generated from abstract specifications. The system, called automatic programming expert (APE), constructs executable and efficient programs from: (1) algebraic specifications of abstract data types, and (2) abstract algorithms given as conditional term-rewrite rule systems with terms built up from operation symbols of the abstract data types involved.

It is an experimental system devised to develop methods for codifying a rather broad extent of programming knowledge required to construct implementations of data types and algorithms.

The APE system consists of two subsystems:

- ADTCOMP codes algebraic specifications of abstract data types as executable INTERLISP programs.
- ALGCOMP constructs executable INTERLISP programs from abstract algorithms given in terms of conditional term-rewrite rules, with terms made up from operation symbols of abstract data types being implemented by ADTCOMP.

In both ADTCOMP and ALGCOMP, programming knowledge is codified in terms of production rules. Both subsystems contain rule-manipulation packages providing an interface for interactive experiments and modifications of the production bases.

In this production system a production rule is of the form < test > → < action >. The researchers evaluate < test > against a condition which is or is not satisified by the database. If the < test > is satisfied, the rule is applied by executing < action > on the database. One possible effect of < action > is to alter the database.

Further information about specification language, automatic coding of algebraic data type specifications, and implementation of abstract algorithms is given by Bartels (1981).

A total of 40 people (17 at Kaiserslautern) are involved in this expert systems effort. The others are at Karlsruhe, Munich, and Essen. Two Symbolics machines, manufactured by LISP Machines, Inc., Cambridge, MA, are used in the work. The machine language is an expanded version of LISP.

Other areas of application for expert systems are under development:

1. An expert system is being developed in internal medicine. Starting with the information a physician gathers on a first visit. The system guides the physician through subsequent diagnosis to test for verification of the initial hypotheses. The system includes risk analysis and cost analysis. The test case now under development is for chest pain. A second system for liver and stomach disease is also beginning. When completed, the system will be installed in Freiburg hospital (Puppe, 1983).

2. Another expert system is being developed for Daimler-Benz to be used for fault detection in engine tests.

3. A system will be developed for use in planning, configuration, and construction. It will be similar to a system now in use by Digital Equipment Corporation for configuration of VAX computer systems.

The system for planning, configuration, and construction being planned at Kaiserslautern will be used in civil engineering for conceptual design. It will be based on qualitative reasoning and nonmonotonic reasoning--i.e., step back and restart, modifying the entire approach as necessary. The developers say the system "will be built on top of" computer-aided design. A system is expected to be ready by August 1984.

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3/12/84

IMAGE-ANALYSIS SYSTEMS AT THE TECHNICAL UNIVERSITY OF BERLIN

by J.F. Blackburn

Industrial image-analysis systems will be widely used for applications

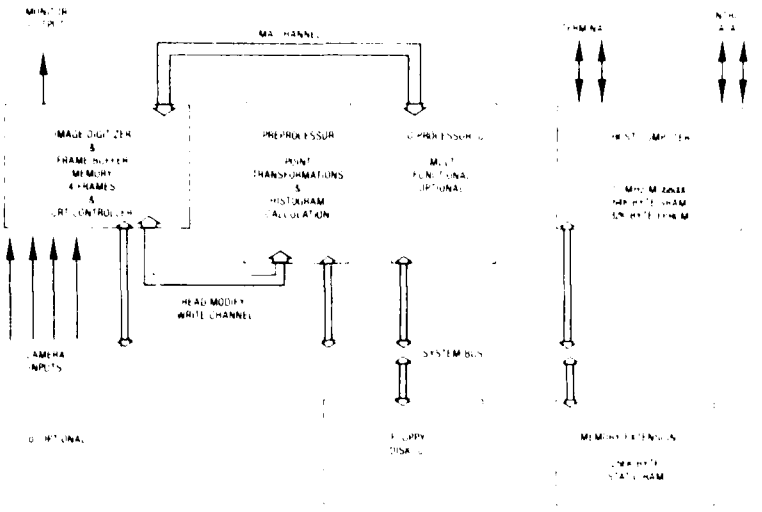

Figure 1. P256 vision system.

such as flaw detection in food processing and industrial manufacturing, measurement and classification in quality control, and robot vision. All of these applications require the stages of preprocessing, segmentation, feature extraction, evaluation, classification, and image understanding. However, the methods and algorithms used may vary considerably.

Since inexpensive microcomputer systems lack the necessary processing power and super-mainframe computers are too costly, real-time image analysis requires special-purpose hardware in order to be cost effective. Even so, the range of application must be large enough to justify the special-purpose hardware.

In image preprocessing and segmentation procedures, the operands are arrays of gray-scale values, and the results of segmentation are binary images. Feature extraction and evaluation are operations on arrays; however, the results are lists made up of extracted features and their attributes. So at the higher levels of image analysis, namely pattern matching and classification, the required algorithms are list-processing procedures. One can take advantage of the commonality in some of the processing steps.

Multiprocessor Architecture

A multiprocessor architecture designed for image analysis has been developed by Wolfgang Giloi and colleagues at the Technical University of Berlin. It is marketed by International Robomation/Intelligence, Carlsbad, CA, under the designation IRI P256 vision system (Figure 1). The architecture is similar to that of the STARLET system (see page 303).

An operation whose argument is a single gray-scale value is called a point operation. Such operations can be performed by dedicated hardware during image digitizing and storage in a buffer storage. A point operation can be repeatedly applied to an image already located in the buffer storage in a read-modify-write mode of operation, each time requiring one refresh cycle. Some examples of point operations are nonlinear transformations of the gray-scale values, including histogram calculation, contrast enhancement, background suppression, and single-level or multi-level thresholding. In Figure 1, the processor for this purpose is called a preprocessor for point transformation and histogram calculation.

A pipeline processor operating in the single-instruction, multiple data (SIMD) mode is used for image preprocessing, segmentation, and feature extraction. This is a multifunctional processor consisting of:

- A set of functional units (adders, multipliers, comparators)
- A set of address generators
- A microinstruction control store and sequences
- A fast buffer memory for intermediate values and results.

There is a microprogram for each function in the control store to generate the appropriate address sequences

for fetching operands and storing results as dictated by the algorithm employed to carry out the function. This allows a comprehensive "library" of standard programs to be performed by the same co-processor; and the microprograms share, to a large extent, the hardware resources of the processor.

A specific co-processor dedicated solely to fast Fourier transform (FFT) calculations can be a part of the system.

A way to reconcile the requirements of list processing with SIMD processing is to have a specific list processor that operates on an associative memory of sufficiently large capacity.

The system can be made more general by adding a pipeline processor for general-purpose vector processing. The host computer is a general-purpose processor. It executes operating-system functions and application programs. Functions of the data structure types executed by the specialized co-processors are performed by the host computer in the sense that the host initializes the appropriate co-processor operation. The host is a Motorola MC68000 single-board computer.

Data-structure types are introduced at the hardware level. Data types are collections of data objects of a given type and a set of functions applicable on the objects. In data-structure types the objects can be arbitrarily structured data objects that are subjected to the transformations of the type in their entirety. Physically, a data-structure object is a memory segment in the machine--i.e., an appropriate-size address space. Such memory-segment objects can be referenced through a segment address mode. The entire data-structure object is referenced in the instructions pertaining to such objects. Substructures or single elements of a structure are accessed through application of access functions. Additional descriptor information must be added to enable the hardware to execute the functions of the data-structure type. Examples of data types are: gray-scale matrix; signal vector (to be subjected to FFT); vector (single-precision, floating-point representation); vector (double-precision, floating-point representation); and lists of variable length.

Communication Structure

The system of sharing a central communication memory in which the processors of the system are given access to a common memory via a central-memory bus is used. This has the advantage of offering under any circumstances a guaranteed memory access time. A central arbitration logic allocates to each processor requesting access to memory an integer multiple of a basic time slice. A bus organized in this way is called EASYBUS (Externally Allocated Synchronous Bus). Bus allocation can be performed in a round-robin fashion or according to a priority scheme. EASYBUS allows connection of up to 15 processors at a transmission band width of 40 megabytes per second.

The P256 vision system uses 8-bit gray-scale in picture analysis. It can perform 200 million operations per second of the type used in picture analysis-fixpoint add and multiply. The system can perform an FFT operation in 100 ms. (For other information on picture analysis, see BYTE 37-12:444-447 [1983].)

Reference

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3/2/84

EARTH SCIENCE

SEISMOLOGY, DISARMAMENT, AND STORM WAVES

by Robert Dolan, Jr. Dolan is the Liaison Scientist for Geology and Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.

A comprehensive nuclear test ban treaty has been the aim of international disarmament negotiations for more than 20 years. The Limited Test Ban Treaty of 1963 prohibited nuclear explosions in the atmosphere, outer space, and underwater. The treaty did not, however, include underground nuclear tests, because in 1963 verification seemed impossible.

Underground nuclear explosions can, at a distance, only be detected through observation of the pressure waves that are generated and transmitted through the interior of the earth--much like the waves generated by earthquakes. For

this reason seismology has been essential in establishing verification methods for a nuclear test ban treaty.

In 1967, the US proposed to the Norwegians the construction of a large seismic observatory in Norway. The observatory was to be an array station consisting of more than 100 seismometers distributed over an area about 100 km in diameter. This array would then serve as an "antenna" that could be focused on signals from seismic events, both natural and nuclear, in various regions of the earth. Construction of the Norwegian Seismic Array (NORSAR) was completed in 1970, and the station has been in continuous operation since then. The observatory has recorded more than 50,000 earthquakes worldwide and more than 400 presumed underground nuclear explosions conducted by the US, USSR, China, France, and India. NORSAR produces a monthly summary of seismic events which is now distributed to more than 25 countries.

NORSAR is one of the world's largest and most advanced seismological research stations. The US wanted the array to be in Norway because of the proximity of the USSR; however, the site is ideal geologically (located on the crystalline rock of the Scandinavian Shield) for detection of seismic "events" throughout the northern hemisphere. In fact, for many regions of the world, particularly Eurasia, NORSAR detection performance is unsurpassed, and research is continually under way to further improve the system.

In addition to monitoring seismic events, NORSAR supports and encourages research and experimentation for a reliable verification system that would be acceptable to all parties of a test ban treaty. The observatory has thus developed into an international center for research, with visiting scientists participating from Eastern, Western, and nonaligned countries. This research has resulted in 350 publications and technical reports over the past 10 years. Among the contributions have been improved techniques in detecting and locating low-magnitude seismic events and improved methods to discriminate between low-magnitude earthquakes and low-yield nuclear explosions. The emphasis on small seismic events is the main focus because of the similarity between low-yield nuclear explosions and earthquakes.

The NORSAR research efforts have also included investigations on general seismological problems, in particular the development of techniques in exploring for oil, gas, and ore resources. Research is also being conducted on assessing earthquake hazards for industrial installations, such as nuclear power plants, large dams, and offshore oil platforms and pipelines.

While visiting NORSAR recently I was shown several routine seismic records as well as examples of "events." One problem with NORSAR is the separation of noise from the event signals. The records I was shown had a wide variation of signal amplitude that appeared to be persistent through time, but that varied significantly over periods of several days to weeks. When I asked about the source of this effect that they called "noise," I was told that the station had a built-in problem from North Sea waves breaking along the Norwegian coast. The waves send through the rocks steady pulses of energy which are then detected and recorded by the NORSAR seismometers 100-km away. When I asked if anyone had considered using these records to investigate wave climate along the Norwegian coast, the answer was no. Since the array can also focus on a range of directions, it would seem that with several calibration wave gauges on oil rigs working in the North Sea it would be possible to regionalize the Norwegian coast and establish a "wave climatology" for Norway. The database is excellent--with long-term and consistent results over almost 15 years. The width of the signal for waves during quiet sea-state periods is substantially and seemingly systematically different from the width for periods of storm waves. Two weeks later, while talking with Dr. M.J. Tucker of the UK Institute of Oceanographic Sciences, I asked if he knew of anyone who had worked on seismic records for North Sea wave research. The answer was, "Oh yes, we did work on that question 20 years ago and gave up in frustration due to the complex configuration [geology] of the coast. Calibration is impossible." So much for waves and seismic records.

3/13/84

EDUCATION

PHYSICS AT LEADING PRC UNIVERSITIES

by R.L. Carovillano. Dr. Carovillano, formerly at CNR, London, is Professor of Physics at Boston College.

Physics teachers from the US recently visited several leading universities and technical institutes in the People's Republic of China (PRC). For background on this trip, see *ESN* 38-5: 255 (1984). Visits were conducted similarly at each institution. A high-rank-

ing university official who spoke English fairly well headed a group which met our delegation and handled introductions. Our group consisted of 20 to 25 people, and about 10 to 15 additional Chinese university officials and physics faculty members were present at each meeting. Typically, no more than about three or four Chinese would speak at the meeting. The highest ranking Chinese official present, usually a vice president, would give a brief history of the institution and a description of the educational program. This was followed by an open question period and a tour of selected facilities.

High school graduates wishing to undertake higher education are required to take a nationwide competitive examination prepared under the auspices of the Ministry of Education (ESN 38-5:259 [1984]). Competing students rank their preferences of universities to attend but really enter a draft since it is the university that selects enrollees. The entrance exam is broad and comprehensive, and includes sections on physics, English grammar, and Russian grammar. This article deals with three of the most selective Chinese universities: Peking University and Tsinghua University in Beijing and Fudan University in Shanghai.

Tsinghua University

Tsinghua University was founded in 1910. Originally it was a comprehensive university but was reorganized into a technical institution in 1952 with the help of the USSR. The curriculum emphasizes technical and engineering courses of study. The university has 18 departments, including physics, chemistry, nuclear engineering, chemical engineering, and electrical engineering. Basic science and mathematics are taken by all students and are used in thesis and project work. Only the brightest students are able to change field or major after entering the university.

Tsinghua University has about 10,000 undergraduates, 1000 graduate students, and 3000 faculty members, of whom about 1000 are tutors--roughly equivalent to a lecturer in the US. Most Chinese universities have a 4-year undergraduate program, but Tsinghua is one of the few that requires 5 years.

The MS program requires a thesis and takes 2 years to complete, though 3 years is not uncommon. The PhD program has been recently instituted and requires about 3 years beyond the MS.

The physics department was reorganized last year. The department has about 160 faculty members, few of whom have the doctorate. About 30 percent of the faculty is female, none at the rank of full professor. The faculty is separated into groups that include nuclear physics, solid state physics, theoretical physics, modern optics, atomic and molecular physics, and liquid crystal physics.

About 2000 students enter the university each year, and all take physics. First-year physics lectures are to classes of up to 300 students. Each department asks for a physics course for its own students. Students with different majors tend not to be mixed in class. Engineers take at least three semesters of physics and physics laboratory.

Physics majors study physics each year. Mathematical physics is taken in the third year. Fourth-year courses are in subjects such as nuclear physics, quantum optics, solid state physics, statistical physics, and quantum mechanics. The quantum mechanics course was characterized as "tough, but not up to [the] book [by] Schiff." The fifth year is spent full time at thesis work. About 50 majors will graduate this year. About 10 percent of the graduates will enter the MS program by passing the entrance exam, 10 percent will stay on and work as assistants, and the others will go on to industry or prepare to teach in a middle school.

Undergraduate laboratories were well equipped. Much of the equipment is made in China. British- and US-made equipment was also in evidence. Setups included Bragg diffraction and Michelson-interferometer experiments for second-year students; and Mössbauer apparatus was used in projects by fourth- and fifth-year students. Research equipment included a nuclear reactor built by the faculty, a tandem accelerator that produced 2-million-volt protons or helium nuclei for scattering or scintillation experiments, and an x-ray facility using copper for the study of phase transitions.

Peking University

Peking University was founded in 1898 and is located on a pleasant campus. It is perhaps the most famous and prestigious university in the PRC and was described as the "Harvard of China." Our reception was headed by the Deputy Chancellor of the university and included the vice chairman and several professors from the physics department.

There are 24 departments at Peking University, about half in the sciences and applied sciences and half in the humanities and social sciences. Peking has about 11,000 undergraduates and 1200 graduate students. The number of

faculty and researchers at the university exceeds 2700. The library claims a collection of 3.5 million volumes and has seats for more than 2000 students in 16 reading rooms. In addition, each department has its own limited library holdings and reading rooms.

Peking faculty members hold visiting appointments at many US universities, including Arkansas, Boston College, Columbia, Cornell, Michigan, Purdue, and Texas. About 30 percent of the select group of students chosen for physics graduate study in the US by the prestigious CUSPEA program are from Peking University. The CUSPEA program is sponsored and run by a consortium of US universities. A graduate appointment at a CUSPEA institution normally includes full financial support for at least 3 years. Peking University has established a number of research institutes in recent years to foster advanced work in selected areas. Newly formed institutes are in mathematics, solid state physics, theoretical physics, heavy ion physics, physical chemistry, computer science and technology, molecular biology, and remote sensing.

The undergraduate degree is obtained in 4 years. The MS degree requires 2 to 3 years of study, and the PhD 2 to 3 years more. Undergraduate and graduate students come from all over China. Graduate students are chosen mainly from the result of written and oral exams administered by Peking faculty members.

In 1952 the physics departments from Tsinghua University and Yanjing University were merged with the one at Peking University to form a single department. The department has about 600 physics majors, with about 150 to 160 freshmen entering each year. About 20 percent of the majors are female. Approximately 110 physics majors graduate each year. About two-thirds of the graduates go on to graduate school in physics or other technical areas, and the others go to work at institutes or in industry all around China. Physics graduates from Peking University hold significant positions in education, science, and industry throughout the country.

In eight semesters the physics major takes only 10 courses (plus physical education) other than physics and mathematics. The physics major takes four courses in English and two courses each in history, philosophy, and political economics. The English courses are 4 hours per week, and the others are 2 hours per week. Advanced required courses include theoretical mechanics, statistical physics, electrodynamics, quantum physics, and solid state physics. Courses emphasize theory, possibly to an excess. Laboratory course work is required each semester. A large number of physics electives are offered and may be taken during the final three semesters of the program. The eighth and final semester is dedicated to thesis work and elective courses.

The department has about 60 graduate students; about 30 new students enter each year, including many of the department's own undergraduates. Research areas are low-temperature physics, semiconductors, quantum optics, magnetism, metal physics, solid state spectroscopy, and theoretical physics. Other departments at the university offer additional research opportunities in fields such as nuclear physics, quantum electronics, atmospheric physics, space physics, and astrophysics. Most graduate students do their thesis research at the university, but some (and an occasional undergraduate) do research at the nearby Academica Sinica, the Chinese academy of science. Since graduate education was resumed in 1978 after the cultural revolution, about 60 PhDs in physics have come out of Peking University. Most of these have gone on to research careers at the Academica Sinica or have taken university faculty positions; the others have taken positions in industry.

Fudan University

Fudan University was founded in 1905 and is located outside of Shanghai's extremely populous inner city. We met with the vice president and several physics professors and staff members in the physics building, which is one of the largest on campus. The physics department is the largest at the university. Fudan has 16 departments that include nuclear science, electronic engineering, and management science in addition to physics, chemistry, and biology. Engineering has only recently been separated from physics. In addition, Fudan has eight research institutes and a computing center. Fudan University has a strong reputation in the sciences and social sciences.

About 6000 undergraduates and 500 graduate students are enrolled at the university. The student body is totally residential. There are no charges for tuition or fees; a small food charge, about $10 per month, is required. Young people are encouraged to marry late, and very few students are married. Married students live off-campus at their own expense. A bit less than 40 percent of the students enrolled at Fudan University are from the Shanghai area; the

others come from all over China. About 20 percent of the student population is female.

The university has more than 2000 faculty members, including about 400 professors and associate professors and 1000 lecturers. The monthly salary range is about $225 to $500 for professors, and somewhat less for associate professors. The range for lecturers is about $125 to $175 per month. There is no faculty union. Individuals do not have automobiles in China, but the university can provide a car to an individual or group for approved requests. Older faculty members are given priority in such matters. A local school bus also operates for the faculty. Mostly, however, faculty members use the ubiquitous bicycle for getting around.

Faculty members are encouraged to attend and participate in international conferences. The university also plans to sponsor international conferences of limited scope--since a maximum of only 300 participants can be accommodated locally.

The undergraduate program takes 4 years. Required courses are in social science, philosophy, and foreign languages. Most students study English, and a few study Japanese or Russian. Science and philosophy majors take physics, but many arts majors do not. Graduate school studies began in 1981. The MS and PhD are available only in certain disciplines. Common graduate entrance examinations are given with Peking University and another institution. About 130 graduate students from Japan and western countries are enrolled at Fudan University. The planned enrollment growth of the university is at the rate of 8 percent per year. Programs in science, management, and economics will expand.

The university library has about 2 million volumes and about 200,000 bound editions of newspapers and magazines. Physics and most other departments have their own library facilities and a small annual library budget (about $6000). The university library budget is about $400,000 per year. Chinese books are inexpensive (about $1 to $2 per book); printing quality is poor. Texts used in the university are mostly by Chinese authors. Foreign texts are used as reference books--either in English or in Chinese translated from the English.

Summer sessions at Fudan University are active but are mainly for students from other institutions or middle-school teachers. Many summer students are from the Shanghai Normal University, and some are from the recently founded Shanghai University, conveniently located in the central city.

The physics department faculty includes 10 professors, 40 associate professors, and 200 lecturers and assistants. About 30 percent of the faculty comes from other universities, and the others are graduates of Fudan University. Teaching loads are 3 hours per week for professors and associate professors, and all faculty members are expected to do research. The department began a PhD program in 1982. The MS program is also new and has so far graduated two classes. A total of 80 graduate students have been enrolled in the graduate programs to date. The MS program takes on about 30 students per year. MS graduates become lecturers at a university or go into industry.

The physics faculty is experimentally oriented, and the ratio of graduate students in experimental versus theoretical physics is 3 to 1. Departmental research laboratories are in surface physics; vacuum physics, including electron optics and beam devices; nuclear physics, which includes a 4-MeV Van de Graaff accelerator and nuclear magnetic resonance facilities; semiconductor physics; laser physics; theoretical physics; and low-temperature physics and superconductivity. The department also has industrial ties providing research opportunities for faculty members and graduate students. In addition, the department has joint programs with local industry, where undergraduate student theses or projects can be done. The department sponsored a conference for Asian science teachers in 1982 and plans an international conference for physics teachers in 1984, which 12 Americans are expected to attend. Departmental visitors last year came from Bell Laboratories and many distinguished universities, including the University of Tokyo, Brown University, the University of Chicago, the University of Illinois, MIT, and Princeton University.

The physics department enrolls 200 or more freshmen majors each year. All majors begin their program with a 2-year general physics course and a special 2-year mathematics course. The physics is taught in one large class that breaks into recitation groups of about 40 students. The large lecture class format is not used for mathematics. First-year physics includes mechanics, electricity, and heat; the second year includes electricity, optics, and atomic and nuclear physics. Introductory laboratory is required and not geared to the lecture course. The laboratory apparatus is mostly developed and built

in China. Standard experiments, including several old-fashioned engineering types were performed in rather a cookbook manner. Topics included the coefficient of thermal expansion, measurement of the earth's magnetic field with a Hertz coil, Coulomb's law, the pendulum, damped harmonic motion, and sound. Demonstrations were done primarily in the classroom with good staff help and visual effects. Demonstrations included Newton's rings, a large hologram, optical rotation, electrostatics and quantization of charge, Coriolis force, and coupled oscillators.

The program is very intensive, with two semesters per year and 22 weeks per semester. The physics courses have four lectures and one or two recitation periods per week. Lab meets for three hours, once a week.

Third-year physics courses include theoretical mechanics, electrodynamics, statistical physics, and quantum mechanics. Laboratory primarily deals with modern physics. An interesting requirement is that each student must build a Franck-Hertz tube and determine its operating characteristics. Other experiments are beta decay, determination of the lifetime of positronium, and laser experiments in three areas: polarization measurements and laser effects on materials, the Zeeman effect using a 1000-G magnet and obtaining a (e/m)-determination, and holography.

In the fourth year, special courses are offered to students in selected groups. The courses include semiconductors, laser physics, and solid state physics, which is widely taken. The final semester is for thesis work in the research areas mentioned above. Most theses are experimental, but a few are theoretical.

3/27/84

ENGINEERING

SIGNAL-PROCESSING PROGRAM AT IMPERIAL COLLEGE

by R.L. Carovillano. Dr. Carovillano, formerly at ONR, London, is Professor of Physics at Boston College.

Signal processing is a discipline that has emerged in part from the practical needs in science and other fields to solve complex problems using computers. The primary tasks in signal processing involve algorithms and computer architecture. (An algorithm is the precise sequence of steps to use on a given device to achieve a desired output or solution from given input data; computer architecture is the assemblage of logical elements in a computing device.) Problems in signal processing may involve some aspect of topics such as communications, signal reconstruction, image processing, distortion, noisy signals, network topology and control, database manipulation, and remote sensing.

The signal-processing program at the Imperial College of Science and Technology (University of London, UK) is part of the Electrical Engineering Department. The personnel in the program include two faculty members, two postdoctoral research assistants, two research assistants, 10 graduate students pursuing the doctorate, and four additional students doing a master's thesis or a senior undergraduate project. The faculty members are Dr. A.G. Constantinides, who heads the group, and Dr. R.H. Clarke, whose background is in microwaves. Both Constantinides and Clarke are readers, which roughly corresponds to a research professor in a US university. Constantinides is well known for his work in digital-filter design techniques. He has authored books and published many papers in the area.

Current research projects involve fast signal processing, numerical transforms, and studies in speech, images, robotic vision, and networks. The research given most emphasis today is on architecture, image processing, speech processing, and other applications. The program in robotics has just started. Three graduate students are working on image processing and two on speech processing. More would be done in the latter area if more support and equipment were available. Advanced work is going on in the areas listed below.

- Fast signal-processing algorithms and architectures. Activities include developing "massaged" hardware algorithms, designing simplified interconnection and control architecture, and targeting for advanced technology insertion.
- Number-theoretic transforms. Work includes applications to high-speed signal processing, inclusion of word-length and sequence-length constraints, and the development of efficient hardware designs.
- Signal-processing algorithm partitioning. Work here includes partitioning by means of graph-theoretic

techniques, modeling of "signal flow graphs," and development of a real-time "signal queue" architecture.

- Digital filter design. Investigations include the determination of finite word-length effects, optimal design of constrained coefficient digital filters, and the design of three-dimensional spatiotemporal video filters. This is a significant area of research that receives funding and helps support the group's operations. The task here is to digitize a degraded version of a given signal that is used for efficient storage and transmission. The tightened information is to produce a satisfactory representation of the original signal.
- Speech bandwidth compression. Work here is to develop speaker-recognizable medium bandwidth speech, and efficient low bit-rate speech coding.
- Image bandwidth compression. Work here is to extract image features, develop overall composite source models, and perform human psychophysical visual modeling under rate-distortion constraints. It is fundamental to determine the rate-distortion function of a signal, i.e., the relationship between the available channel capacity versus the degree of degradation. An analytical solution for the rate-distortion function is known only for a gaussian source. Constantinides has developed an algorithm to obtain the solution for the rate-distortion function phenomenologically (not analytically) in a signal-dependent manner.
- Image restoration. Effort here includes nonstationary composite image modeling and noise reduction by optimal two-dimensional segmented Kalman filtering.
- Image-feature extraction. The task is to obtain object detection by means of a two-dimensional spectral estimation. High resolution extractors are being developed. Applications are made to coding, restoration, and recognition.
- Robotic vision. Efforts here are to obtain optimal processing of stereo vision and depth-of-field extraction, and to develop a three-dimensional visual model.
- Optimal network expansion. The effort here is to obtain an optimal expansion of existing communications networks. Applications of developed algorithms are made to specific problems.

Several of the active research areas overlap with regard to method and required facilities, and individual projects have more and more common ground. Spectral methods are useful wherever the need is to abstract a signal buried in a noisy background. Both coding and signal reconstruction can use the composite source model. The common ground between projects promotes interactions among workers and makes for an active research group.

Of special importance is the work of the signal-processing group on high-performance computing structures. The main problem with very-large-scale integration tasks is not so much the speed of the devices as getting the information in and out of the system. Thus, the approach in this research effort is to develop a high-throughput architecture, using concurrent and parallel processors, so that a comparatively slow machine can provide a high-information-rate output. The following features of the structures are being considered: signal-queue drive, control flow spatially separated from the data flow, a high data/procedure ratio, affordable control tokens, simplified interconnection, virtual system configuration, closely coupled network architecture, self-organization and self-synchronization, and cybernetic capabilities. Benchmarks in the program are in adaptive acoustic processing and particle mechanics. In the latter case the objective is to provide simulation models with an increase in grid size from 100×100 to at least 1000×1000 to calculate particle motion more adequately. The current efforts are supported by the UK Ministry of Defence and the US Naval Research Laboratory; the work deals with new architecture for a high-throughput-rate sonar system.

The signal-processing laboratory is well equipped in cramped quarters. Computing is currently done off-line, but the researchers expect to have real-time computing capabilities soon. Obtaining suitable equipment has been less a problem than providing suitable space for its use. Equipment includes a 68000 UNIX-based host system, a good image-capture and -display system partially built in-house, and a developing real-time signal-processing subsystem.

In terms of doctoral degrees produced, external support, and breadth, the Imperial College signal-processing program is productive and successful. Seven doctoral theses have been completed in the 1983-84 academic year that relate generally to the development of techniques and methods to deal with signals and information. Thesis titles are: "Techniques for Transmultiplexor Design"; "Analysis of Some Linear

Networks With Time Varying Components"; "Frequency Domain Coding of Speech"; "Composite Source Models for Multi-Dimensional Signal Processing"; "Finite Wordlength Linear Transform Digital Filters"; "Adaptive Data Compression With Memory"; and "Algorithms for Network Expansion." The next thesis expected will deal with number theoretic transforms.

In science and engineering, qualified UK graduate students are provided with government support for 3 years, the "expected" time to complete the doctorate. The average time to complete the PhD at Imperial College exceeds 3 years, and this creates considerable hardship and stress on students at the completion stage of their work. Extensions in support are possible but difficult to obtain. The average time for the doctorate in signal processing at Imperial College is about 4 years. Because of the large student load and other responsibilities, Constantinides took on no new students in the 1981-82 academic year. This will produce a gap in the thesis production rate beginning next year.

3/13/84

ENVIRONMENTAL SCIENCES

CLIMATE AND THE GREAT POTATO FAMINE OF 1846-50

by Robert Dolan. Dr. Dolan is the Liaison Scientist for Geology and Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.

Historical climatology of the Irish Potato Famine of 1846-50 is the most recent project of Prof. H.H. Lamb (Climatic Research Unit, East Anglia, UK). During the famine the population of Ireland decreased by 50 percent. More than 1 million people died of starvation and diseases associated with malnutrition, and hundreds of thousands immigrated to several nations. Most of the people of Irish descent in the US today can trace their family roots back to those terrible conditions in Ireland in the late 1840s and early 1850s.

How did what they call the picture? According to Lamb, the first step toward the Potato Famine did not occur in Ireland, but rather in Belgium in 1843. In that year Belgium's potato crop was so poor that the government decided to import some new strains from South America to improve production. The new potatoes arrived in 1845, but along with them was a disease, potato blight. Interestingly, a similar blight with origins in South America swept through the potato fields of the US in the early 1840s. By 1846 hot easterly winds in the summer carried the blight from Belgium to the British Isles. What caused the greatest problem for the UK, and especially for the Irish, was that 1846 was an exceptionally long, hot, humid summer that resulted in perfect weather for prolonged impact, or entrenchment, of the blight. The blight was also destroying potato crops on the continent (France, Denmark, Germany, The Netherlands, and Belgium), but in 1846 northern winds and cooler weather occurred much earlier there than in the UK just across the channel. Lamb says this was a unique summer for Western Europe.

The blight lasted for 6 years--most nations were able to adjust by planting different crops. Ireland could not. The population in the 1850s was so great in Ireland that the land available for support of large families was something like 3 to 4 acres per family. Because of the poor quality of the land and the marginal climate for most high-yield agriculture, potatoes were the only crop that would yield sufficient food value to support the population. But the blight devastated the potato crops, and there were no surpluses to fall back on. The effects--starvation and disease--were immediate and lasted for several years. The population of Ireland decreased 50 percent in 6 years and has never reached the level of the mid-1800s. Even today, when traveling in Ireland one can see the outlines of potato fields on steep slopes that haven't been tilled since 1850. One of the questions underpinning Lamb's research is what is the probability of such climatic conditions occurring again--and if they did, what would be the consequences with the highly specialized grain crops we have in Europe today?

3/13/84

MATERIAL SCIENCES

COMPOSITE MATERIALS RESEARCH IN EUROPE: WEST GERMANY'S DFVLR

by Tsu-Wei Chou. Dr. Chou is Professor of Mechanical Engineering at the University of Delaware.

This is the first article in a series on European research in composite materials. Research by the German Aerospace Research Establishment (DFVLR) is featured this month.

July's *ESN* will examine work in France; in August research in The Netherlands and Denmark will be highlighted. For detailed information about composites research in the UK, see *ESN* 37-4 through 37-12. In addition, Office of Naval Research, London, Report R-5-84 provides an overview of European research on polymers and composites.

DFVLR's Materials and Structures Research Department, headed by Dr. C.J. Winter, comprises the Institute for Structural Mechanics, the Institute for Aeroelasticity, the Institute for Space Simulation, the Institute for Materials Research, and the Institute for Structural Research and Design. Research in composite materials is being conducted at the three institutes discussed here.

Institute for Structural Mechanics

The Institute for Structural Mechanics is in Braunschweig; Dr. Bergmann is the institute's director. It has West Germany's highest concentration of research in advanced composites; the emphasis has been on carbon-fiber-reinforced plastics. Major efforts are in computational aspects of composite structures, damage mechanisms of graphite/epoxy laminates, composites under environmental conditions, and fatigue of composites. The institute is very well equipped with composite fabrication and testing facilities.

A concerted effort has been made in order to quantify the magnitude and distribution of interlaminar stresses. An extensive finite-element analysis has been performed using the ASKA program; higher-order three-dimensional finite elements allowing for anisotropic elastic properties were used. A very fine element grid was required because of the steep stress gradients. Finite-element software for layered composite shells has been developed at the institute. The main component is a two-dimensional, triangular, hybrid finite element accounting for membrane and bending action, and surface tractions at the upper and lower faces. By stacking several of these elements above one another, one can model a laminate in great detail. After a failure criterion and a failure progression rule have been included, crack opening displacements can be computed. The coupling of fine grids with more coarsely modeled regions is achieved by special coupling elements. Computational capabilities also have been developed for the optimum design of cylindrical shells, for the repeated buckling of cylindrical shells, and for the buckling of orthotropic sandwich panels.

In the study of damage mechanisms of graphite/epoxy laminate, researchers are interested in inspection methods for determining the state of damage in the specimens before, during, and after mechanical testing. The methods used include ultrasonic techniques, acoustic emission, x-ray radiography, microscopy, residual strength and stiffness determination after fatigue, crack opening displacement, and crack length. Whenever possible, these investigations were carried out in real time or with only short interruptions in the loading history. Damage progressions in laminates during both quasistatic-loading and fatigue-loading conditions have been examined in great detail.

Composite behavior under environmental conditions has been investigated for moisture, temperature, and radiation. In the case of radiation, the physical origins of the damage may include radiation-induced matrix decomposition and reduction in the length of macromolecules due to expansion. The resulting mechanical effects are the degradation in mechanical response (e.g., reduction in strength and stiffness) and aging elongation (e.g., increase in elongation). The institute evaluated test results of outdoor weathering of composites in terms of the accumulated amounts of UV-B radiation of epoxy reinforced by woven fabrics of graphite fibers, glass fibers, and two kinds of aramid fibers. Scanning electron microscopy showed initial cracks in the smooth surface of the resin after only a few weeks, with rapid subsequent growth and branching. It seems that small flakes of degraded resin gradually peel off from the fibers and are carried away by wind and rain. Under further exposure, the resin is completely removed from the surface and severely damaged between the fiber layers. Single fiber breakage is visible, and considerable reduction in laminate strength could result.

Institute for Materials Research

The Institute for Materials Research is in Köln-Porz; Prof. W. Bunk is the director. The institute studies metallic and nonmetallic structural materials and high-temperature materials. The major thrusts of research are:

1. The correlation of microstructures and mechanical properties of titanium alloys and high-strength aluminum and aluminum-lithium alloys.
2. Fracture mechanics studies for establishing failure criteria for thin-walled metallic structures, for evaluating methods and limits of application of linear-elastic fracture mechanics to metals and composites, and for developing alternative methods of determining K_{IC} values of metals based on cylindrically and prismatically shaped specimens with chevron notches.
3. Fatigue under service loading conditions, and high-temperature fatigue behavior of titanium alloys.
4. Stress corrosion cracking of metals with emphasis on accelerated test methods and the repassivation of aluminum-alloy surfaces freshly generated in aqueous electrolytes.
5. High-temperature ceramic engineering materials, focusing on the development of Si_3N_4 using reaction-bonding, hot-pressing, pressureless sintering and hot-isostatic pressing; on the effects of microstructure on thermal shock and oxidation resistance; and on the development of methods for characterizing fracture behavior.

Research in composite materials has been performed on both metal- and polymer-matrix composites. In metal-matrix composites, the study of tungsten-fiber-reinforced nickel-based superalloys has focused on strength losses at high-temperature--losses due to the diffusion of nickel from the matrix into the tungsten fibers along the grain boundaries; the effect has not yet been suppressed by diffusion barriers.

It has been demonstrated that tungsten fibers reinforced with ZrO_2 can delay the nickel-induced grain growth of the recrystallizing tungsten fibers. However, the diffusion of nickel along the grain boundaries, and thus the strength loss, cannot be avoided.

Research also has been performed on directionally solidified eutectics. The system--a $Ni_3Al(\mu')$ precipitation-hardened nickel matrix (γ) reinforced with molybdenum fiber (α)--is a potential material for aircraft turbine rotor blades. Creep investigations on this γ/γ'-α system have demonstrated a stress-rupture strength equal to that of complex alloys with the same base material. The molybdenum fibers [illegible] change their shapes and sizes even after annealing at 1200°C; this is also true when there are strong local temperature gradients. The eutectic composite system is also superior to the oxide-dispersion-hardened high-temperature alloys, which tend to form brittle cracks due to temperature gradients.

Another aspect of metal-matrix-composite research is the study of SiC-fiber-reinforced titanium alloys. The objectives of the work are: (1) to investigate the interfacial behavior using advanced microbeam and surface analytical methods, and (2) to optimize the interface structure through changes in processing conditions. The production of SiC/titanium composites (Ti-6A-4V, pure titanium, Ti-Al and Ti-Mo alloys) on a laboratory scale has been carried out by diffusion bonding and by power metallurgical methods using hot isostatic pressing. A reaction zone a few microns thick at the fiber and matrix interface has been observed under all process conditions. The composition and thickness of this layer are controlled by the processing parameters and by the alloying elements of the matrix. The variation in the concentration of the elements in the interface area indicates a very complex structure of this zone, consisting of a multilayer arrangement of various reaction products (silicides, TiC). The Young's modulus of Ti-6Al-4V alloy has been increased by 50 percent by the addition of 14 percent of SiC fiber.

In polymer-based composites, the focus has been on continuous graphite and Kevlar fibers as well as aligned short fiber systems. One area of active research is the identification, characterization, and analysis of damage events and mechanisms associated with low-amplitude fatigue loading of graphite-epoxy laminates for large numbers of cycles. The purpose is to correlate the degradation in stiffness, strength, and life of the laminates with the observed damage events and mechanisms. Another area of graphite-composite research is intended to understand the statistical strength characteristics of laminates. Graphite-epoxy cross-ply laminates show multiple cracking in the 90-degree ply before final rupture occurs. With the aid of a piezoelectrical load cell, crack formation has been measured as a function of the applied load in $(0_2/90_2)_s$, $(0_2/90_3)_s$ and $(0_2/90_4)_s$ laminates. With these experimental results and a shear lag analysis to account for the nonhomogeneous stress distribution in cracked 90-degree plies,

it was possible to estimate the Weibull strength distribution of the respective 90-degree ply. It was found that the shape factor increases with decreases in the thickness of the 90-degree plies. This is attributed to a suppression of defect growth close to the 90-degree interface. Because of the changing shape parameter at decreasing ply thicknesses, the research concludes that a description of the thickness effect by a Weibull shape parameter is not feasible.

Another area of research is aligned, short-graphite-fiber-reinforced laminates. Composites with 3-mm graphite fibers as well as neat polyimid and polyethersulphone matrix systems are investigated for their static and fatigue properties. Special attention is given to examining the damage development due to the initiation and growth of internal cracks. X-ray radiographs and scanning electron micrographs are extensively studied to evaluate the damage mechanisms.

Finally, the institute is cooperating with Delft University of Technology in The Netherlands on research and development of a new hybrid material. The material is obtained by adhesive bonding of a number of thin aluminum sheets of aramid weaves, producing an aramid-reinforced aluminum laminate (ARALL). ARALL shows very favorable fatigue-crack growth properties and has a high tensile yield strength. When compared with monolithic high-strength aluminum alloys, ARALL offers weight savings up to 30 percent, combined with improved damage tolerance. The improvement of the fatigue-crack growth rate is due to the restraint on the crack opening by uncracked fibers in the wake of the crack. This effect becomes more active when favorable residual stresses are introduced by prestraining the whole laminate in the plastic region of the aluminum alloys. Analytical work is also in progress for calculating the stress intensity factor by taking into account delamination and residual stresses.

The institute is also highly interested in research on ceramic matrix composites.

Institute for Structural Research and Design

The institute is in Stuttgart; Prof. Gruninger is the director. The research on composite materials is devoted to applications in aircraft and automobiles. The following discussion is based on a recent summary of activities prepared by the institute.

In the area of aircraft applications the major work includes the following projects.

Alpha Jet Horizontal Stabilizer. Under a cooperative project between the DFVLR and the Dornier Company, manufacturing concepts were developed for the leading and trailing edges of a tail unit made of graphite-fiber-reinforced plastic. Due to their high specific strength and stiffness, graphite composites are perfectly suited for use in lightweight aircraft structures. The goal is to develop an economical manufacturing process in which all structural elements (ribs, skins, fittings) were cured in only one fabrication step in the autoclave. The stabilizer built by the Dornier Company was 14-percent lighter than the metal unit, and the number of structural elements could be drastically reduced (215 to 80). The institute is now developing wings of graphite-fiber-reinforced plastics for the Alpha Jet and is performing qualification tests of subcomponents.

Composites for Commercial Aircraft. In a government-sponsored program, Messerschmitt-Bölkow Blohm (MBB/UH) is developing a graphite-fiber-reinforced plastic spar box for the A300/310 vertical fin. Before the modular construction method proposed by MBB can be used, some basic work has to be done: investigations of preconsolidating prepreg lay-ups outside the autoclave; measurements of the properties of graphite-reinforced-plastics laminates; manufactured from prepreg, which were subjected to repeated temperature changes; and determination of thermal expansion of graphite-reinforced-plastic materials in order to calculate or to avoid internal stresses of the vertical fin generated by heat.

Crash Worthiness of Aircraft Fuselages. Because of the increased use of composites in fixed-wing aircraft and helicopters and because of the need to fulfill crashworthiness requirements, one must know the crash behavior of these materials. In a 16-m drop test facility at the institute, composite structural elements are impact-tested to obtain a basic understanding of the energy-absorbing processes and dissipating properties.

Composite Structures for Gliders. The economical use of graphite-reinforced plastics in gliders requires an increase of the currently certificated stress level (200 N/mm^2 to 400 N/mm^2) and an increase of the service life from 3000 hours to 6000 hours. To verify these values, researchers investigated the inner wing of the high-performance glider NIM-BUS 2 in about 12×10^6 load cycles. After the dynamic investigation, in the final static wing test a safety factor of 1.9 was achieved (1.5

was required). This justifies the confidence placed in graphite-reinforced plastics.

In the area of composites for automotive applications, the first primary structure developed was a two-piece drive shaft. The metal tube sections were replaced by composite components to reduce weight without increasing costs. Composite bumpers and wheel drive shafts have also been developed and tested up to the point of drive testing. These activities stimulated detailed studies of composite applications in the engine itself, where car economy can be substantially improved by weight reductions in the oscillating and rotating masses.

In 1981 the institute, working in cooperation with the auto industry and supported by the Ministry of Research, started the joint development of graphite-reinforced-plastic gudgeon pins, connecting rods, and crankshafts. Design concepts of these and other engine components show that weight reductions of 50 to 70 percent are attainable. Different types of composite gudgeon pins are developed and have already been tested in a one-cylinder diesel engine. The composite gudgeon pins are 60-percent lighter than the conventional metal pin. The composite pins consist of a graphite-reinforced-plastic core enclosed by a thin metal bearing bush.

The development of the graphite-reinforced-plastic connecting rod resulted in a 45-percent mass reduction over the normal steel rod. The forces produced by the mass are carried by the graphite-reinforced-plastic loop, while the graphite-reinforced-plastic core carries the compression forces. Because a division of the graphite-reinforced-plastic rod for the crankshaft bearing bushing would increase the weight, a one-piece rod was designed. This means that either the crankshaft must be manufactured in pieces, or the rod must be manufactured in place around the crankshaft. The graphite-reinforced-plastic connecting rods have already been tested outside the engine and soon will be tested in the engine. The mass of the graphite-fiber-reinforced-plastic crankshaft (designed for the composite drive elements with an aluminum piston) is only 45 percent of that of the steel crankshaft (designed for metal elements). The design concept is ready for evaluation. Several fabrication methods have been successfully tested.

The institute is interested in developing fiber-reinforced ceramic matrix composites, and it has experience in the use of ceramic materials. A fine example of this expertise can be found in the design and fabrication of ceramic components for gas turbines. To minimize the detrimental characteristics of ceramics--such as small critical crack length, high crack propagation rate, brittleness, and low tensile strength--researchers at the institute designed the turbine wheel so that the ceramic blade and hub components are under compression. Results of tests on the wheel confirmed the idea of using innovative designs for the effective use of brittle ceramics.

3/21/84

OCEAN SCIENCES

DENMARK'S NORTH SEA CENTRE FOR FISHERIES RESEARCH

by Chester McKinney. Dr. McKinney is the Liaison Scientist for Underwater Acoustics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from The University of Texas at Austin, where he is Senior Research Scientist at Applied Research Laboratories.

Denmark is the home of a most unusual and remarkable new research and educational complex. Located at Hirtshals on the north coast of Jutland, some 260-km northwest of Copenhagen, the nonprofit North Sea Centre (NSC) or Nordsoecentret is made up of nine independent organizations which have the common purpose of being involved in the fisheries business. These groups include four research and development institutes, two educational units, offices and show rooms for 30 industrial firms, a conference center, and a unique museum-aquarium (see also *ESN* 37-2:85 [1983]).

To properly appreciate the NSC one needs to know something of its background. Hirtshals, a thriving small town with a population of 8000, is the home base for about 500 fishing vessels, ranging in displacement from 5 to 1500 gross tons. Businesses include auction sheds, processing plants for fish to be used for industrial purposes and for human consumption, and associated fishing equipment factories and stores. Hirtshals is the largest Danish port for consumer fish. These fish are served

all over Europe within 24 hours after being sold at auction. Development of the harbor started in 1917; it was completed in 1932 and has been expanded several times. In 1977 local business and government people began to develop the concept of an integrated research and educational center to serve virtually all aspects of the fisheries business from the eggs to the final processing of the fish catch. The NSC was chartered in 1979 by a combine of fishermen associations, local businessmen, and local government. Mr. Sten Sverdrup-Jensen, an economics professor from nearby Aalburg University, took leave to develop the plan and prepare a proposal for partial funding from the European Economic Community's (EEC) Regional Development Fund. The proposal was successful, and the EEC paid for about 40 percent of the buildings' cost of 140 million Danish kroner (equivalent to $19 million, where DKr 1.00 is about $0.11). Construction started on the 15,000 m² structures (on a 110,000 m² site) in March 1981 and is essentially complete at this time. Official dedication by the Queen of Denmark is scheduled for June 1984. The time from concept to operation was extremely short.

The NSC is the landlord and housekeeper for the tenant institutes to be described next.

Danish Institute for Fisheries and Marine Research (DFH)

DFH is a government institute under the Danish Ministry of Fisheries, with headquarters in Charlottenlund Castle, a northern suburb of Copenhagen. The director is Dr. Joergen Moeller Christensen. My host at the castle was Dr. Hans Lassen. The total institute staff is 130 (exclusive of the crew of the research vessel *Dana*), with only about 25 at Hirtshals. The staff includes 35 scientists. The 1983 budget was DKr 26 million (exclusive of operating expenses for *Dana*). In addition to the assessment work and fish-stock measurements, the institute has extensive work in the biology of fisheries, the recruitment of fish stock (i.e., the processes going from eggs to small fish), and the development of theoretical models for the whole fisheries cycle. DFH primarily is concerned with fish and their environment. The work includes the monitoring of fish catches for size and species; to aid in this the institute operates eight small laboratories at major Danish ports.

For research, they use the large, modern, research ship *Dana* for ocean cruises to assess fish populations in waters near or important to Denmark. This ship obtains fish samples using a variety of trawls. A minor research program is aimed at developing means for using standard down-looking depth sounders to remotely assess fish density and fish species. Most of the effort is directed toward signal processing and data analysis and interpretation rather than development of special sonar equipment. In the present phase of research they are attempting to correlate the sonar data with the actual fish catches. I believe that they are using only first- and second-moment statistics; but that may prove to be adequate, even with fairly low resolution sonar, provided the fish density is low. Most of the time they work with data obtained at two frequencies, although they can collect data at four frequencies (18, 38, 50, and either 120 or 200 kHz). Data can be collected using either hull-mounted transducers or a towed body with down-looking transducers.

The institute also is interested in determining the effect on fish of noise generated by the fishing vessel and by the trawl.

Commissioned in 1981, *Dana* is home-ported at Hirtshals; the ship's dimensions are: 78.5-m length, 14.7-m beam, and 5.9-m draft. The displacement is 2500 gross tons. Individual cabins, each with private bath and toilet, are provided for the crew of 28 and for 11 scientists. The cruising range is 14,000 nmi at 12 kn. The ship operates at sea about 220 days each year, with most of the cruises being devoted primarily to fish-population assessment. The ship is well designed for this purpose with its trawls, sonar equipment, wet and dry labs, chemistry lab, and computer complex (a PDP-11-34). The electronics equipment is mostly by Simrad.

Danish Institute of Fisheries Technology

This institute is one of 20 independent nonprofit research and development institutes affiliated with the Danish Academy of Technical Sciences (ATV). Each institute has its own board and operates with funds from a variety of sources in government and industry. The Institute of Fisheries Technology was established in 1982, and the director since then has been Sverdrup-Jensen. This institute deals with the technology of catching fish. A primary emphasis is placed on developing improved trawls (and other types of nets) and on learning how best to employ the equipment. Documentation is another facet of the program, and this includes the compilation and analysis of data (from some 200 databases), preparation of economic and

market surveys, and publication of data and other information. A good library is being developed. A third facet involves the teaching of a variety of short courses relating to the operation of fishing equipment.

The major facility of this institute is the circulating water flume tank, the largest in the Western world. This tank, which became operational in 1982, has a total length of 30 m and a measurement section 21×8×2.7 m. It is used mostly for testing scale models of trawls and for demonstration and instruction. A commonly used scale factor is 8 to 1. Since many of the trawls are the bottom-following type, the floor must move at the same speed as the water. Maximum speed is 1.2 m/s which (scaled) is more than adequate for testing and demonstrating most trawls. (A typical bottom-trawling speed is 3 kn.) The flume, a very impressive facility, is well instrumented with good data recording equipment. A viewing window 20×3 m is suitable for photography, video taping, and direct observation by a class of students. The flume manager is Mr. David Wileman, who also was in charge of the design. Prior to joining the institute he worked for 10 years with the UK White Fish Authority lab at Aberdeen and with the flume at Hull. The operating staff of seven includes a fishing-gear technologist and a model maker. Already about 70 different model trawls have been built and are kept in stock. I understand that the current lease rate for the flume is about $300 per hour, but this depends on a number of factors. A great deal of information can be obtained quickly and at modest cost. Already the flume has proven its value in developing trawls, learning the most economical speed for effective trawling, and providing demonstrations and instruction. The institute also can do full-scale testing at sea.

Another major facility, scheduled for operational use in 1984, is a testing lab to evaluate materials and fishing equipment under full load and under a range of climatic conditions from arctic to tropical.

It should be noted that the flume is not well suited for acoustic measurements nor for the introduction of live fish into the test section.

Technological Laboratory of the Danish Ministry of Fisheries

This government laboratory is involved with the storage, processing, and use of both industrial and consumer fish. It is capable of full-scale testing of catch handling and processing. The program includes research and development, and courses are taught. A current research project concerns the development of low-phosphate (skeleton removed) fish meal. A major use of the meal is to feed fish, and the usual high-phosphate variety is a serious pollutant. Headquarters for this laboratory are at the Danish College of Technology, but about half of the total staff works at Hirtshals.

Division for Marine Aquaculture

This unit studies the recruitment of fish and the feeding and rearing of fish. It has two large saltwater tanks, each 25 m in diameter by 5-m deep.

Educational Departments

In addition to the educational roles of the institutes just discussed there are two other schools. The Aalburg University Centre offers an MS degree in Fisheries Technology. Normally about 3 years are required beyond the baccalaureate to complete this course, which is stated to be at the Danish Civil Engineering Degree level. Aalburg University, located 60-km south of Hirtshals, is only 10 years old. It offers the BS degree in a variety of subjects. The North Sea College is called a high school, and it offers a wide variety of courses on fisheries, the natural environment, natural resources, and ecology. The lengths of these courses range from a few days upward. Any Danish citizen can attend these courses, tuition free.

Conference Center

The NSC has all of the usual facilities for a conference center, including an auditorium, lecture halls, meeting rooms, exhibition space, and dining facilities. On-site housing for 50 people is available, but there are several resort hotels in the area also.

Division of Industry

This unit will be expected to lease space at the NSC to industrial companies involved in the fisheries business for sales offices and equipment demonstrations. Equipment manufacturing is excluded, but future research and development activity is encouraged. The division is scheduled for opening by summer 1984, and space has been leased to 30 companies, mostly from Denmark and other Scandinavian countries.

North Sea Museum

This privately owned nonprofit unit is a unique combination of aquarium and museum. The museum part emphasizes current fisheries practices, not historical

ones. The static and dynamic displays are outstanding and include all aspects of fishing, such as three-dimensional scale maps, models of trawls and ships, a full-size ship bridge, navigation equipment, radar, communication, and fish processing models. Extensive use is made of video tape machines. Attendants are pleased to show tapes of special interest to visitors, and the tape library is good and growing. The aquarium part is quite good and includes a large outdoor seal pond with glass viewing windows below the water. One could spend a long time in this museum before exhausting all it has to offer. The legends and voice recordings are in Danish, but this is not a serious drawback for foreign visitors. And there were a large number of visitors in the museum during my visit on a cold March day.

Marine Animal Bionics Centre

At present none of the NSC institutes are doing research work with marine mammals, but they hope to change this situation. Plans have been developed for a facility which would include four tanks, ranging in size from a 14-m-diameter cylindrical tank to a 42×24-m ellipsoid tank. The researchers plan to work with porpoises, dolphins, seals, and small whales. The construction cost is estimated to be about DKr 14 million, with an operating budget of DKr 4 million. I understand that funding has not yet been obtained.

The NSC is a remarkable organization and is unique in its coverage and integration of the many facets of the fisheries business. The combination of research, development, testing, demonstration, sales, education, and entertainment within a single small complex is an interesting concept and, although it is just getting into full operation, it appears to be working well.

3/22/84

MARINE GEOLOGY IN ISRAEL

by Robert Dolan. Dr. Dolan is the Liaison Scientist for Geology and Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from the University of Virginia, where he is Professor of Environmental Sciences.

Three institutions are responsible for most of Israel's research in marine geology and geophysics: the Israel National Oceanographic Institute (INOI) in Haifa, the University of Tel Aviv, and the Department of Marine Geology and Geomathematics of the Geological Survey of Israel in Jerusalem. This article summarizes investigations under way at INOI and at the University of Tel Aviv.

The INOI in Haifa is the largest and most comprehensive marine science program in Israel. Among their investigators are Dr. Zen Ben-Avraham, a geophysicist well known in North America, and Prof. Victor Goldsmith, a coastal geologist who for several years carried out research along the Atlantic Coast of the US from a base at the Virginia Institute of Marine Sciences.

Z. Ben-Avraham, who holds a joint appointment with INOI and the University of Tel Aviv, is well known in the US for his research on plate tectonics. He has published several review papers in recent years in journals such as *Science* and *Scientific American*. The region of the eastern Mediterranean and the Middle East is an area of rifting and continental collisions, so it has served as an excellent base for his studies.

Ben-Avraham has been working in the Levant Rift Zone, which is a well-exposed and assessable fault zone extending from the Red Sea to the continental collision section of eastern Turkey. Since parts of this structural trend are covered with water, Ben-Avraham has been able to use simpler marine geophysical techniques in his investigations. These studies are the first of their kind in the Lake Kinneret, Dead Sea, and the Gulf of Elat. The Gulf of Elat (Aqaba), until recently one of the least-known segments of the world rift system, is of particular interest because it is one of the few places (the Gulf of California is another) where a mid-ocean ridge system changes into a transform system and runs into a continent. The Dead Sea rift is a plate boundary of the transform type; it has a slight component of opening. As a result, part of its length is marked by prominent morpho-tectonic depressions. The Gulf of Elat is the most spectacular of these. Thus, Ben-Avraham believes the gulf represents an early stage in the formation of a new plate boundary.

A recent geophysical survey included continuous seismic reflection profiling, echo sounding, and magnetic field measurements. A new bathymetric map has been produced which shows many details of the morphology of the gulf (available from J.K. Hall of the Geological Survey of Israel). Most of the Gulf of Elat is occupied by three elongated basins which

strike N20°-25°E. A series of undulations in the floors of the basins produced five distinct deeps.

The seismic profiles indicate that the structure of the gulf is controlled by faulting which has produced rhomb-shaped grabens. A thick sedimentary fill has accumulated; the oldest sediments lie at least 7-km beneath the present level of the adjacent lands. Thus, Ben-Avraham describes the Gulf of Elat as a "spectacular cleft in the earth's crust resulting from the still active rifting of Sinai from the Arabian peninsula." One of the most interesting results of these investigations is that various parts of the gulf experience different types of tectonic activity. Its relatively deep water enables the researchers to study in detail the processes of continental rifting using marine geophysical techniques, which are much less difficult to use than continental techniques.

Ben-Avraham's research includes investigation of the structure and tectonics of the eastern Mediterranean, a region long recognized as tectonically complex. In fact, geophysicists and geologists cannot even agree about whether the crust under the eastern Mediterranean is oceanic or continental. At least six plates--the Turkish, Aegean, Ionian, African, Arabian, and Sinai--are recognized as interacting in this region. Ben-Avraham's research is directed toward two problems--the nature of the contintental margins and the structures of the basins. They have found, for example, that the basin between Israel and Cyprus is pure oceanic crust only 7-km thick overlain by more than 12 km of sediment. Cyprus is underlain by continental crust.

These studies of the eastern Mediterranean have served as the basis for new ideas about collision processes. Ben-Avraham, in collaboration with colleagues at Stanford University, has extended the results of his eastern Mediterranean investigations to other regions of collision processes. In most converging plate boundaries the crusts are either continental or oceanic. The crusts are mixed only in a few places. The Middle East is a region in which the crust in nonuniform. A mixture of continental and oceanic crust occurs, with subduction and collision taking place next to one another. To clarify the structure in this region, Ben-Avraham organized a research program to perform deep sounding of the crust using seismic refraction. His study of the collision processes of oceanic plateaus and continental margins includes investigating the mechanisms of emplacement of ophiolites. Ophiolites, recognized in most orogenic belts in the world, are fragments of oceanic crust and upper mantle which have been thrust into the continental margins at consuming plate boundaries. The mechanism of emplacement is unclear; several concepts have been proposed to explain ophiolites as part of normal consumption of oceanic crust.

Ben-Avraham proposes a model of emplacement which is based on collisions of small bodies with the continental margins. These bodies can be microcontinents or oceanic plateaus of various orgins. He suggests that "this mechanism occurs everywhere" and that it is responsible for emplacement in zones of continental collision and in zones on underthrusting. Associated with this is the elevation pattern of volcanoes--a pattern that shows a very simple two-part division. Volcanoes built on a continental crust are distinct from those built on an oceanic crust. For continental volcanoes the elevation above sea level is variable, and the height of the volcano edifice is uniform; the converse is true of oceanic volcanoes. Therefore, relief patterns along an arc may provide a way of investigating the nature of the crust in subduction shear zones. The method can be calibrated as more detailed data on the nature of crusts become available.

Slip rate along faults and other tectonic attributes--such as seismicity, depth of trench, age of oceanic crust, and dip of Benioff zone--do not seem to control the volcanic processes. Even when the volcanoes are far inland from subduction zones, as in Central America and Canada, their relief is consistent with that in comparable areas. This suggests, according to Ben-Avraham, that the mechanism controlling volcanic relief is a simple one. He says, "The difference between oceanic and continental volcanoes may be explained if melting, or ascent instability of melt, is basically controlled by buoyance. In the continent where the depth of melting is within the elastic part of the lithosphere, this pressure is a function of the local overburden and produces a fairly constant height over the existing topography. In the oceans, melting occurs well below the elastic part of the lithosphere, where pressure is controlled by depth below sea level. This leads to uniform volcano elevation with edifices which simply reflect the local depth of the ocean floor."

Ben-Avraham's current research has moved onto the continental shelf off the coast of Israel. Using side-scan sonar, he and his associates are mapping

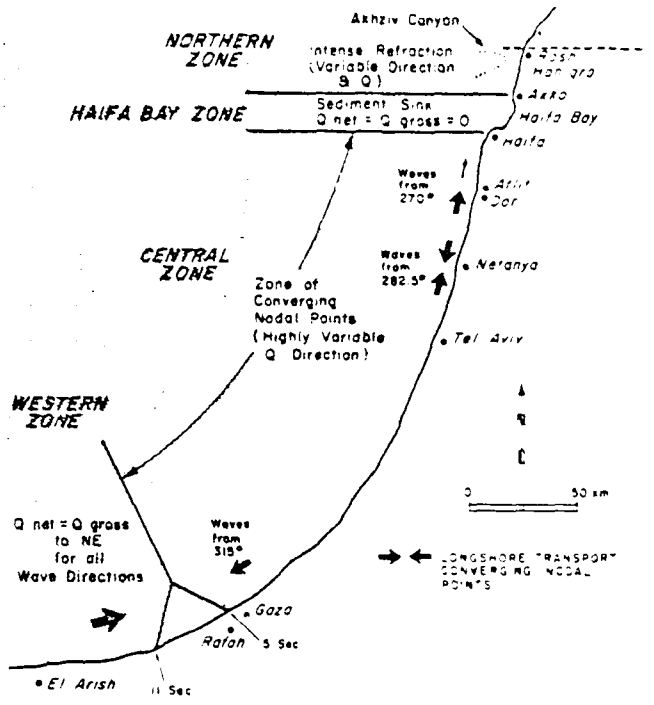

Figure 1. Longshore sediment transport model of the southeastern Mediterranean coast.

structural trends in considerable detail. Although this new project was started only recently, preliminary results show that the patterns of sedimentary deposits (packages) across and along the shelf are fault controlled.

The main thrust of Victor Goldsmith's studies is to establish a sand budget for the Israeli coast. This called for a wave climatology of the relationship between wave actions, currents, and Mediterranean storms.

The results of his 3-year study are now being reported in various journals (see references); he has also produced a *Wave Atlas*.

The wave climate of the Israeli coast has been based on visual wave observations and gauge measurements, including wave height, period, and direction from six different sources during 1948-80. Relationships between the various data sets show that the visually observed data reflect the same seasonal, climatic, and longshore trends as the measured wave data.

The overall results, in brief, are that the Israeli coast has three wave seasons: the high-wave winter season for December through March; the low-wave months of May and October through early November (both of these seasons are periods with northwest waves); and the intermediate-wave months of June through September. April and the second half of November are transitional. Superimposed on these are short- and long-term weather and climatic variations.

Based on the wave-climate data, Goldsmith and Golik (1980) have developed a longshore transport model of the Nile Delta-Israeli Coast as part of their sediment budget studies. They divide the province into four zones, as shown in Figure 1.

The first zone extends from the Nile Delta east to Gaza. Here, all sediment transport is to the east due to the east-west orientation of the Mediterranean (which here is parallel to the shore), and to the western wave source.

The central zone is from Gaza to Haifa Bay. Because of the change in shoreline orientation, this zone is characterized by converging longshore transport nodal points that shift along the coast in response to changes in wave direction. This zone may be further subdivided; south of Tel-Aviv net transport is to the north, whereas between Tel-Aviv and Haifa net transport is either approximately zero, or even slightly to the south.

Haifa Bay is the northern limit of the transport of Nile sediment; the bay acts as a sediment sink because of lower wave action and because topographically the bay is a structural graben or basin.

Nile River sediment is transported within this province by currents which move in a counterclockwise direction. Goldsmith's analysis of LANDSAT satellite images suggests velocities of about 18 cm/s, with clear evidence that Nile Delta sediment is still being transported along the shelf and coast toward the north despite the cutoff of sediment supply by the Assuan Dam in 1964. The Nile Delta continues to erode at a rapid rate, but the eroded sediment appears to move uninterrupted toward the north.

Among the most interesting aspects of the coastal studies under way in Israel is the excavation and reconstruction of historical harbors and cities that are now either isolated from the coast or submerged. For example, it has been proposed by some investigators that ". . . the entire coastal zone, at least from Ashqelon to Caesarea, was downwarped and submerged under the Mediterranean waters. . . . Later the area east of the fault (the present coastline) was uplifted to its present position. This tectonic event probably occurred later than 700 yr B.P.[before the present]." Although tectonics may explain some of the geomorphic variations along the coast of Israel, these ideas have not been universally accepted. However, Ben-Avraham's side-scan sonar records clearly suggest major tectonic activity on the shelf parallel to the coastline, so a "sinking" of some of the Roman sites would not appear to be out of the question.

The entire harbor of Caesarea, built by Herod some 2000 years ago, is now submerged under about 2 m of water, suggesting either a sea level rise or tectonic activity. The archaeologists working in collaboration with marine geologists are now convinced that the submergence is due to faulting.

Finally, Goldsmith's inshore bar studies deserve mention. The coast of Israel is an excellent location for these investigations because nearly all types of bars along the world's coasts are found there. The bar occurrences are enhanced by the local dissipative wave-energy conditions, which are due to the low nearshore slopes and high wave steepness. Sequential bar development in the moderate wave energy, microtidal, dissipative beaches of the southeastern Mediterranean includes, in order: multiple bars, ridge and runnels, transverse/oblique bars, and outer crescentic and nested inner crescentic bars. The results of Goldsmith's work on inshore bars has been published in several journals over the past 5 years. Goldsmith himself is not carrying this research further, but one of his PhD candidates is using sequential photographs and box cores to concentrate on bar changes over relatively short periods of time.

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3/16/84

PHYSICS

ACOUSTICS AT THE TECHNICAL UNIVERSITY OF DENMARK

by Chester McKinney. Dr. McKinney is the Liaison Scientist for Underwater Acoustics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1984 from The University of Texas at Austin, where he is Senior Research Scientist at Applied Research Laboratories.

Denmark has a fairly extensive effort in acoustics research and development--considering the size of the country and the small number of individuals involved. Most of the major acoustics areas

are represented, including architectural, noise control, underwater, physical, and medical, with the work being done in universities, research institutes, and industry. Very little of the work is sponsored by military agencies. Research budgets are not large by US standards, but the groups seem to be efficient, and the record of publication in archival journals and symposia proceedings is impressive. The firm of Bruel and Kjaer (B&K) has been a premier developer and manufacturer of fine acoustical instruments (used worldwide) since its founding a few years after World War II.

This article is an update on acoustics research at the Technical University of Denmark (see *ESN* 34-11: 511-512 [1980]), which is under the leadership of Prof. Leif Bjorno. About 90 percent of the funding for the Technical University of Denmark (TUD) comes from the Ministry of Education, with the remaining being derived from contracts and grants from industry, NATO, and the European Economic Community. Bjorno's work is in the Industrial Acoustics Group (IAG), now within the Electrical Engineering Division but likely to move to Mechanical Engineering. The staff is small (about five), and there are about 25 graduate students. However, IAG is involved in cooperative efforts with 20 other research institutes (both government and nonprofit) and companies--so the effective staff of professionals is about 25, not all full time in acoustics. This interconnection of groups is important to the health of R&D in Denmark.

The research program in the IAG divides generally into five areas with considerable overlap. One of the most active areas deals with machinery and combustion noise generation. Projects include valve-generated noise, propeller cavitation noise, flame noise, and hydraulic pump noise. The goal is to obtain a basic understanding of the source of these noises; each project involves both theoretical and experimental work. A 1983 dissertation project by Peter N. Larsen, "Noise Generated by Air Jets From a Rectangular Slit," achieved good agreement between the theoretical model and experiments for air jets issuing from narrow slits (length-to-width ratios of 33 to 100).

The medical ultrasonics program is concentrating on using ultrasound to discriminate between healthy and diseased tissue. The workers hope to achieve this by measuring the nonlinearity parameter of tissue. The nonlinearity parameter relates to the change in the speed of sound as a function of the intensity of the sound and is thought to be different for different states of the same tissue. The nonlinearity results in a distortion of the primary sound beam, which is manifested by the generation of harmonics and subharmonics. Other approaches are to measure the change in the speed of sound as a function of temperature and pressure or to use tomographic techniques. It is desirable to make measurements both *in vivo* and *in vitro*. This work is in progress, but some encouraging results have been obtained. The tissue work is done in the megahertz range. Some earlier work, using high-kilohertz frequencies, dealt with using focused ultrasound to destroy diseased tissue. Most of the medical work is done in association with the Danish Institute of Biomedical Engineering, Glostrup, and with research and teaching hospitals. IAG staff also have worked with the B&K company in the development of medical ultrasonic imaging equipment. One aspect of this work was the development of an electronically scanned array with time-varied focus.

Bjorno and colleagues have been active in finite amplitude/nonlinear acoustics for more than a decade. Bjorno is editor of *Finite Amplitude Effects in Fluids* (IPC Science and Technology Press, London, 1974), the proceedings of a symposium held in Copenhagen in 1973. He has worked on several aspects of nonlinear acoustics, both theoretical and experimental, with considerable emphasis on developing nonlinear arrays for use in the medical and underwater sound projects. One example of the research was to seek means for increasing the very low conversion efficiency (around 1 percent) in generating low difference-frequency sound from high-frequency carriers. By using fluids other than water for the interaction region they were able to achieve power gains of 2 to 3 dB, small but significant.

The underwater acoustics research centers around the propagation of sound in shallow water, an area of practical importance to Denmark. The work is both theoretical and experimental, with the latter taking place in laboratory tanks. Several tanks are available, ranging in size up to 1×1×2 m, including one anechoic tank about 1 m on edge. Several of the tanks are equipped with precision transducer-positioning apparatus and the usual electronic equipment (mostly B&K). The IAG does not have a lake test station (but would like to have one), nor does it do any work on ships at sea. Some of the recent work involves the study of generating and

propagating a single-mode sound beam in shallow water. The source is a nonlinear parametric array.

The transducer and measurements program is important in its own right but also is crucial to many of the other projects. In fact, for several of the cooperative projects the primary contribution of IAG has been to develop special transducers. Dr. Peter A. Levin has been the principal investigator on much of this work. One main line of work has been to develop and build very small ultrasonic probes for medical and other ultrasonic research. Examples are disk transducers (as small as 0.3-mm diameter for use up to 10 MHz) and cylindrical transducers (1.6-mm diameter for frequencies a bit lower). This work led them into experimenting with polyvinylidene difluoride (PVDF) as a transducer material. They have done considerable work on determining the optimal procedures for polarizing and stressing thin film PVDF material. They have made probes as small as 0.6-mm diameter for use up to 10 MHz. For lower frequency operation (up to 200 kHz), they have made larger units (30-mm diameter), using thicknesses of 7 and 30 μm, using both air backing and inert PVDF. One unit was made of folded PVDF to form a 16-layer unit. At present they are working with composite transducer materials, i.e., mixtures of piezoelectric ceramic powder and plastic. They claim to have achieved coupling coefficients (d_{33}) close to those for pure ceramic. This is a joint project with Ferroperm Company. I was not given any details on this work. IAG staff have worked with B&K on several projects involving hydrophones and transducer calibration devices.

The vigor of Bjorno's group is demonstrated by a few numbers for the calendar year 1983. Three PhD degrees were completed (most theses are published in English); two chapters appeared in books, nine papers in refereed journals, and 10 papers in conference proceedings; three reports were published. Admittedly some of these documents covered basically the same projects, but it is still a good record for only seven authors. The staff attended and gave papers at 11 meetings outside Denmark and gave 13 invited lectures in other countries. There were three visiting professors who spent the full year at the university and 10 who visited two weeks or less.

TUD is located about 17-km north of Copenhagen, at Lyngby. TUD is one of the oldest of the seven Danish state universities, having been founded in 1835, with Hans Christian Oersted as the first director. The campus of modern buildings was occupied in 1968. TUD is organized into four major engineering groups (electrical, mechanical, civil, and chemical), with a total of 4500 students and 1000 faculty and research staff. Students enter at about age 19 after having completed 12 years of public school. The basic degree granted is the Master of Science, which requires from 5 to 7 years. About three percent continue for the PhD, which requires about three more years. The BS degree is not granted by TUD, but such is not true for some of the other Danish universities. Adjacent to the TUD campus is the Engineering College, which grants a degree in applied engineering and technology.

The Danish Academy of Technical Sciences (ATV) is an important entity in research and development in Denmark. It sponsors or coordinates a wide range of work and has affiliated with it 20 self-governing institutes and 16 committees and societies. Bjorno is involved with several of these, including the Committee on Industrial Research Education Programme. One unusual arrangement is that a PhD student can do his research work with an industrial company on a special project approved by the committee, the company, and a university supervising professor. The company pays half of the researcher's salary and the ATV the rest. The degree is granted by ATV, with the results of the research being the property of the company. This program started in 1971, and about 70 degrees have been granted to date.

The IAG staff is small and the facilities are modest (offices, laboratory, and a good library and computer), but the research work is interesting and of high quality. The theme is applied research with emphasis on work which will help Danish industry (and Denmark as a whole), but the flavor is that of basic research--and always a blend of theory and experiment.

3/22/84

COMPUTER ANALYSIS OF A TURBULENT MIXING LAYER

by David Mohser. Dr. Mosher is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until July 1984

from the Naval Research Laboratory, where he is Supervisory Research Physicist.

Visual information has always been important in fluid mechanics and is especially so in the study of large-scale structures which develop in turbulent shear flows. The empirical data resulting from observation of such flows is particularly important because they are common to a wide class of problems in hydrodynamics, aerodynamics, reactive-flow physics and combustion, while theoretical understanding is rudimentary. Unfortunately, it has been difficult to extract more than qualitative information from flow-visualization pictures because of the flow complexities--the amount of information in even a single picture is great enough to tax the processing ability of a human observer, and the interpretation of what is seen is subject to operator bias. An analysis of the dynamic development of the flow may require examination of hundreds of sequential images.

Digital image analysis using large-scale computers has been applied to this type of problem in many disciplines (Pratt, 1978). For large visual databases, the computer can be instructed to automatically recognize the relevant information from the images, so that it can objectively sift through the visual data without operator intervention. Now, researchers in Spain have developed digital-image-analysis techniques to recognize the large eddies that evolve in a plane mixing layer. I learned of the research during a recent visit to the School of Aeronautics of the Polytechnic University of Madrid. M.A. Hernan of the Polytechnic and J. Jimenez of the university-associated IBM Scientific Center have developed digital techniques to follow the evolution of eddies recorded in high-speed shadowgraph movies of the mixing layer between nitrogen flowing at 10 m/s and an equal density, helium-argon mixture flowing at 3.8 m/s (Brown and Roshko, 1974). Previous human analysis of the data provided information on eddy motion and pairing, but good quantitative information for comparison with turbulence models was lacking.

Two versions of the computer program were developed by Hernan and Jimenez. The first was interactive, using a display of partially processed images on a color graphics terminal with operator feedback to control the parameters of the process. This version was used to develop and tune the algorithms for the second, or "black-box" version of the code, which permitted no operator control and was applied to long series of consecutive movie frames. As part of the problem of extracting relevant information from the images in a computer-interpretable form, the researchers had to precisely define a few key parameters which could unambiguously be assigned to the complex vortices. Statistical data on these vortex characteristics were gathered with the black-box version and used to compare with known scaling laws for turbulent eddy formation.

Every third frame of the 1119 frame movie was digitized using a Perkin Elmer 1010 MP flat-bed microdensitometer with a 9-bit A/D converter, and put onto tape. This sampling rate was sufficient to follow individual eddies in a number of frames as the structure moved across the field of view. Each frame was converted into a 120×417 pixel matrix. Each digital image was then filtered to remove scratches and any gradients in the background density. The resulting image was comparatively noise-free but still contained unnecessary information. Since only the shape of the mixing region was desired for analysis, the image was further simplified by defining a threshold density above which pixels were associated with the free stream background and below which they were associated with the mixing fluid (Chow and Kaneko, 1972). The resulting classified-pixel image was scanned vertically; the first and last appearance of a pixel containing mixing fluid was noted, and the resulting two curves were displayed. Stages of image preprocessing just described are shown in Figure 1. The final edge detection image (Figure 1d) was further processed to remove spikes caused by stray misclassified pixels. The resulting envelope, a

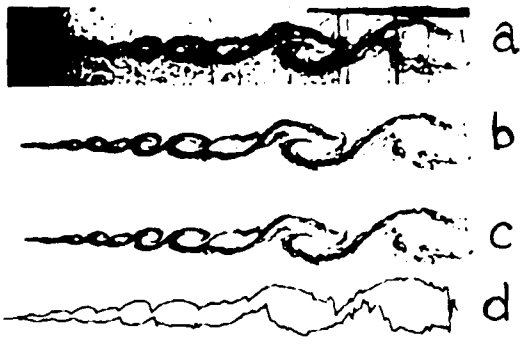


Figure 1. Stages of image processing: (a) digitization, (b) filtering, (c) thresholding, (d) edge detection.

smoothed version of Figure 1d, is the only information for each frame used in the analysis.

By this preprocessing, the pixel matrix containing about 5×10^4 elements was reduced to the two edge-detection curves coded as 834 y-coordinates (two for each of the scanned 417 x-values). The next task was to identify individual eddies as a local "fattening" of the mixing region with the right scale and roughly elliptical shape. This vague description was transmitted to the computer using syntactic methods of pattern recognition.

The two edge curves are examined for extrema, which are then connected by straight lines. Each top and bottom pair of line segments is given a type, in accordance with Figure 2, that depends on the slope of the lines, their divergence, and an "intensity" (the difference between the widths at the beginning and end of a segment pair). By this pro- cedure, pairs are classified as "openings" <A>, "closings" <C>, or "indifferent" <B>. The mixing layer in each frame can then be written as a sentence of the general form <ABAC...-CCAB> which approximates the shape of the edge curves. Reduction rules are then applied to simplify the sentence. The aim of these rules is to isolate units of the form <AC> representing bulges and of the form <B> representing the intervening braids. They are

$$\langle AB\rangle \rightarrow \langle A\rangle$$
$$\langle BC\rangle \rightarrow \langle C\rangle$$
$$\langle BB\rangle \rightarrow \langle B\rangle$$

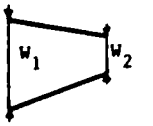
$$\langle A_1A_2\rangle \rightarrow \langle A_1B\rangle \quad \text{if } |I_1| \geq |I_2| \qquad (1)$$
$$\langle A_1A_2\rangle \rightarrow \langle BA_2\rangle \quad \text{otherwise}$$

$$\langle C_1C_2\rangle \rightarrow \langle C_1B\rangle \quad \text{if } |I_1| \geq |I_2|$$
$$\langle C_1C_2\rangle \rightarrow \langle BC_2\rangle \quad \text{otherwise}$$

The rules are applied until no further simplification is possible. An example of the reduction process is shown in Figure 3.

The bulges isolated in this way are not necessarily eddies. To be considered such, they must have the right shape. Each candidate eddy is fitted to a general conic section by a sum-of-squares minimization procedure. When the best-fit conic is an ellipse with a reasonable ratio of semiaxes, and when the approximation error is below a certain limit, the bulge is accepted as an eddy. Once eddies have been identified as ellipses with individual centers and geometries on each frame of film, their evolution can be followed from frame to frame to determine velocity, growth, and merging. Figure 4 illustrates this

SLOPE		DIVERGENCE	TYPE
UPPER	LOWER		
+	-	Any	A
-	-	D>.5	B
-	-	-.5≤D≤.5	B
+	+	-.5≤D≤.5	B
+	+	D<-.5	C
-	+	Any	C



$$D = \frac{2(W_2 - W_1)}{W_2 + W_1}$$

Figure 2. Classification rules for segments.

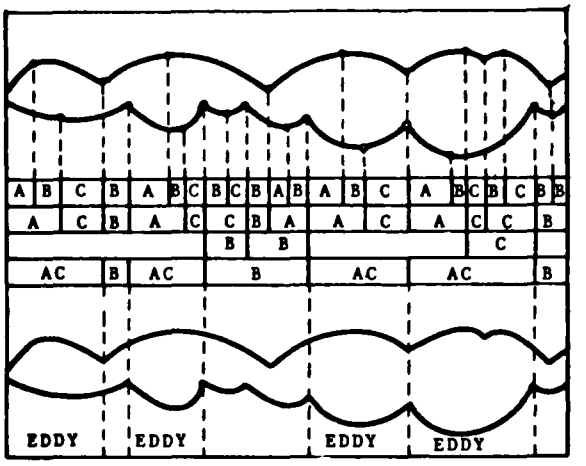


Figure 3. The syntactic simplification process.

evolution and shows several examples of eddy merging.

The dimensions and centers of ellipses for a sample of 2214 structures has been used to gather statistics that characterize the turbulent flow. The major axes of the eddies tend to be aligned to the flow direction with an average tilt of 0.08 radian toward the low-speed side and a standard deviation of about 0.3 radian. The ratio of the two axes is 1.92±0.67, which agrees well with predicted values (Jimenez, 1980). The spreading rate (defined as the change in thickness between the upper and lower tangents to the ellipses) agrees well with water mixing-layer measurements performed under contract to the US Army Research, Development, and Standardization Group, UK (Jimenez et al., 1979). The eddies move with a velocity very close to the arithmetic average of the two free streams. An

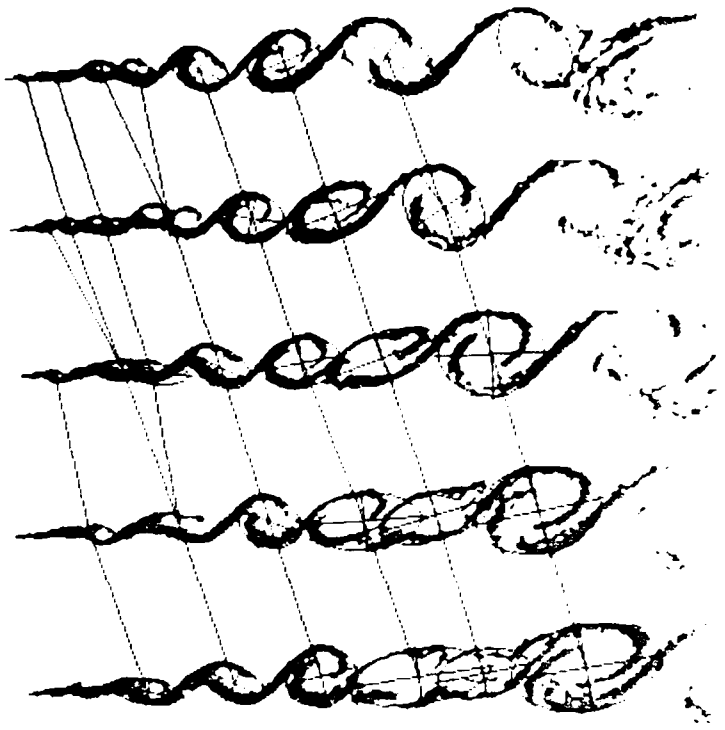


Figure 4. Eddy evolution showing several amalgamations.

interesting structure is observed by constructing a histogram (Figure 5) for the eddy wavelength λ, the distance between eddy centers. Peaks marked II through V have wavelengths 1.5, 2, 3, and 4 times that marked by I. The peaks probably arise from eddy merging and hint at the period-doubling behavior exhibited by many nonlinear, dynamical systems.

The amount of fluid entrained by the eddies during their evolution can be quantified by measuring the eddy areas. Entrainment is an important process because it controls the extent to which reactive components are free to mix. The researchers calculated the relative increase in area resulting from entrainment over the lifetime of the eddies and compared the value to the area increase associated with amalgamation of eddies. They demonstrate that most entrainment happens by passive eddy growth and that the effect of merging is minor. This disagrees with some early models of mixing layer growth and supports models in which fluid is entrained by either irrotational roll-up or turbulent diffusion.

Hernan and Jimenez have demonstrated that their quantitative analysis of flow pictures can provide spatial and temporal information which could not

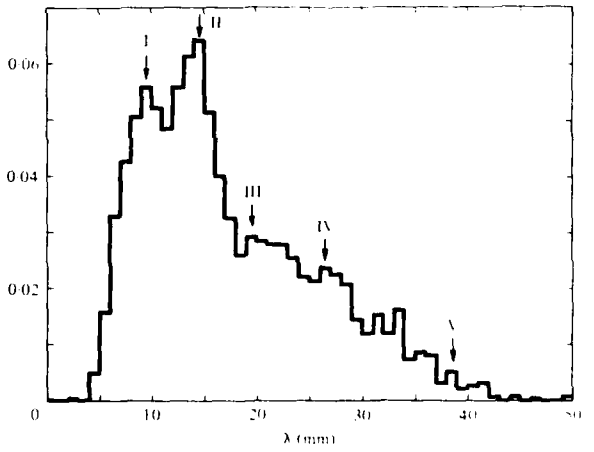


Figure 5. Frequency distribution for eddy wavelengths.

have been obtained with point probes in the flow. Moreover, those results of analysis which can be compared with other measurements are in good agreement. The methods and results are quite efficient in terms of the investment required to obtain data. Each frame takes about 5 minutes to digitize. The preprocessing requires about 8 seconds per frame of CPU time on an IBM

370/155. Later processing, working with only the compressed information of the edge images, requires about 2 minutes for the entire sequence of 373 frames. By developing precise automated procedures to identify key structural parameters, the researchers have quantified a large body of visual data which human processing could only address in a qualitative manner.

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3/27/84

GUERRE D'ETOILE--FRENCH RESEARCH IN ATMOSPHERIC ELECTRON-BEAM PROPAGATION

by David Mosher.

The propagation of relativistic electron beams in the atmosphere for defense has been researched in the US for more than a decade. Funded primarily by the Defense Advanced Research Projects Agency (DARPA), with help from the Office of Naval Research, the Air Force Office of Scientific Research (AFOSR), and the Department of Energy (DOE), the effort has focused on the beam-atmosphere interaction to determine requirements for stable propagation over long distances, and on new types of accelerators tc generate the beams. Last year's famous "Star Wars" speech by President Reagan has given this directed-energy program greater visibility and has stimulated the interest of foreign governments. Now, French scientists from the University of Grenoble I and the Centre d'Études Nucléaires de Valduc have begun experiments designed to test a multifluid plasma code that models the atmospheric response to defense-level beams. I spoke with members of both groups about their research. This article provides some background information and a brief description of the French project.

Background

When an intense relativistic electron beam (REB) is injected into the atmosphere, molecules in the propagation region are ionized to form a conducting plasma channel. The beam's electromagnetic field then induces a flow of low-energy plasma electrons, called the return current, that resistively heats the channel further via ohmic dissipation. If the beam pulse is long enough, the high-pressure channel has time to expand into the surrounding cold gas so that later portions of the beam pass through a higher-temperature and less-dense atmosphere than the beam front. The beam front, entering cool atmosphere of low conductivity, tends to blow up because of electrostatic repulsion in the unneutralized beam charge. The back of the beam, traversing hot plasma with high conductivity, drives a return current comparable to that of the REB and in the opposite direction. (In any good conductor, currents flow in the interior so as to exclude penetration of the magnetic field.) The interaction of the induced plasma current with the surrounding magnetic field can produce resistive instabilities which disrupt beam transport either by an axisymmetric pinching of the beam or by a wandering of it away from the plasma-channel axis of symmetry. To avoid the instabilities, the beam-pulse duration should not exceed the resistive decay time of the magnetic field or the inverse of the beam plasma frequency, two time scales which characterize instability growth. Some propagation scenarios involve a concept called "hole boring," in which the beam is chopped into a train of short, and therefore stable, pulses. Pulses near the head of the train are consumed in establishing the reduced-density plasma environment required for passage of later pulses.

Analyses which hope to realistically model REB propagation must be sufficiently comprehensive to handle the very different conditions of the beam front and back. For a stable and cylindrically symmetric beam, the fields and plasma-channel should be modeled in time and two spatial dimensions--one along the beam axis and one radially away from it. It is difficult to isolate aspects of the problem for ease in analysis because of the interrelations between the beam, fields, and plasma. Stable propagation depends on the correct field and plasma environment. Plasma temperature is determined by REB collisions and Joule dissipation of the return current flow. The fields which drive the return current depend sensitively on the time and space variation of the plasma's electrical conductivity which, in turn, is determined by plasma heating, expansion, and secondary electrons produced

by beam ionization. Thus, treating only one part of the problem requires restrictive simplifying assumptions for other portions.

Researchers at the Los Alamos National Laboratory, the Lawrence Livermore National Laboratory, the Naval Research Laboratory (NRL), and Science Applications, Inc. employ a variety of theoretical and computational methods to model atmospheric beam propagation. Analytic techniques are used to derive dispersion relations for instabilities; particle-in-cell codes model erosion of the beam front due to space charge; and plasma-fluid codes predict the development of return currents, the electromagnetic fields, and the self-consistent plasma conductivity (Lampe et al., 1983). A hydrodynamic theory for turbulence in beam-produced channels has been compared with experiments (Picone et al., 1983), and a detailed model for beam generated conductivity in nitrogen and air has been developed (Ali and Slinker, 1983).

Good modeling is vital to an assessment of electron beams for directed-energy applications because existing accelerators cannot provide defense-level beams. Particle energies must be in the gigaelectronvolt range to penetrate kilometers of atmosphere without excessive collisional beam spreading or energy loss. Beam current densities in the kA/cm² regime are desired for target lethality, and pulse durations should not exceed the nanosecond range to insure stability.

Several REB propagation experiments at low energy are in progress in the US. Multikiloampere beams of megaelectronvolt electrons have been extracted from water dielectric pulse line generators and transported in reduced atmospheres at NRL, Mission Research Corp., and the Sandia National Laboratory. Operating at defense-level currents, these REBs can drive resistive instabilities and create realistic plasma backgrounds to provide data for code comparisons (Greig et al., 1981). Somewhat higher beam energies have been achieved with the Experimental Test Accelerator at Livermore, where beam profiles have been measured using a variety of techniques (Lauer et al., 1983). The Advanced Test Accelerator (ATA), a 50-MeV, 10-kA induction linac now being tested at Livermore will provide the next step in electron energy.

Beams with energies an order-of-magnitude greater than ATA will be required for long-range atmospheric propagation. Conventional gigaelectronvolt, radio-frequency accelerators are too large for mobile deployment. The US Navy supports development of high-current compact ring accelerators appropriate for ship-based operation. N. Rostoker and coworkers from the University of California at Irvine have been experimenting with a modified betatron configuration and have confined a 200-A electron beam for 5000 turns to achieve 1-MeV acceleration. A larger modified betatron has been designed by C.A. Kapetanakos and coworkers at NRL to accelerate a multikiloampere beam to the 50-MeV level. Other more speculative concepts for super-compact accelerators are supported by AFOSR and DOE and are based on charged particle trapping in plasma waves driven by an REB or laser (ESN 37-1:32-38 [1983]).

Theoretical Research at the University of Grenoble

A few years ago, J.M. Dolique, A. Richard, and J.R. Roche of the University of Grenoble I began development of a two-dimensional, axisymmetric fluid code, called PEGASE, to model the plasma channel. The aim was to treat the space-charge effects responsible for beam-front erosion, return current heating and channel expansion with realistic air chemistry. Within the framework of the fluid equations, it was assumed that the beam could be treated as a uniform, rigid cylinder unaffected by the self electromagnetic fields. For this beam model, the code provides the detailed time development and r-z distribution of the channel and self-consistent fields from which beam stability can be assessed.

The code solves the continuity, momentum, and energy equations to obtain density, fluid velocity, and internal energy (or temperature) for each plasma species. Inelastic source terms appear in the equations to model species production by primary beam collisions. The chemistry and atomic physics package includes impact ionization by the primary beam electrons and secondary plasma electrons, electron avalanche processes, radiative and dissociative recombination, charge exchange, and ionization by primary beam bremsstrahlung. The fluid species are electrons, N, excited N, N_2^+, N^+ and higher ionization states. The fluid equations are coupled to the full set of Maxwell's equations with space charge and current contributions from the beam and plasma. The numerical solution procedure employs finite difference techniques for the fluid equations and finite element techniques for the Maxwell's equations.

For Dolique and coworkers, the calculated time and space variation of plasma conductivity $\sigma(r,z,t)$ is a

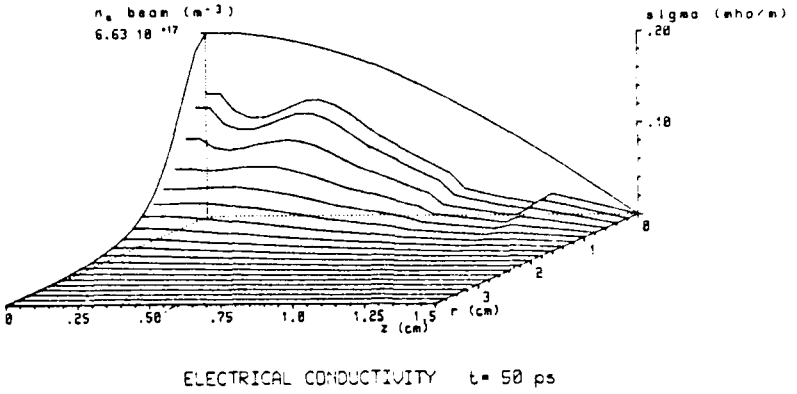

Figure 1. Spatial distribution of plasma conductivity.

primary analysis tool since the growth rates of resistive instabilities depend sensitively on this quantity. The conductivity is a special variable in that it couples two parts of the problem--it links the plasma to the electromagnetic field via a generalized Ohm's law. A major uncertainty in determining σ for short-duration beams is the contribution to it from nonequilibrium secondary electrons whose unknown velocity distribution is generated by primary collisions and rapid time variations. The latest version of the code, called PEGASE III, improves modeling of σ by adding direct beam impact heating to the previously considered resistive heating through a superthermal temperature parameter.

The code is currently running on a CRAY I computer. Calculations have been performed for a 0.5-GeV, 10-kA, 2-cm-diameter electron beam with a duration varying from 0.1 to 10 ns and propagation in a nitrogen atmosphere of variable pressure. A sample result is shown in Figure 1 for a 0.1-ns beam at a time 50 ps after the beam front crosses z=0 from the left. The conductivity increases toward the back of the beam since the plasma there has been heated for longer times. Note also the substantial return-current heating outside the 1-cm beam radius. For such short beams, results confirm that a regime of higher stability results when impact heating is included than would be predicted by resistive heating alone.

Experimental Research at Valduc

Beam propagation experiments have begun at the Commissariat à l'Énergie Atomique (French Atomic Energy Commission) Centre de Valduc at Is-sur-Tille to test the ability of PEGASE to model the plasma channel. Valduc is a nuclear weapons research center with functions similar to some at Los Alamos and Livermore. A portion of the research under the direction of Alain Bernard of the Section d'Études de Criticite et Rayonnements involves vulnerability testing of defense systems of the sort performed in the US by the Defense Nuclear Agency and the Sandia National Laboratory. To this end, Valduc houses a number of oil- and water-dielectric transmission line generators with megavolt output voltages and currents up to the megampere regime. This pulsed-power technology has been employed during the last two decades to produce intense REBs, ion beams, and x-radiation sources (*ESN* 38-4:211-213 [1984]) for defense and inertial-confinement fusion.

The beam-propagation experiments have been carried out on the EUPHROSYNE device, an older generator which can produce a 1.7-MeV, 40-kA electron beam of 75-ns duration and 5-cm diameter. The experiments are described in Richard's University of Grenoble thesis (Richard, 1984). He and Valduc's R. Bailly-Salins performed the experiments. The beam is propagated in a 1.2-m-long, 40-cm-diameter nitrogen drift space of variable pressure. The challenge to the Grenoble-Valduc team, like that faced by US researchers, is to demonstrate that such a beam can provide meaningful results for assessment of directed energy concepts.

From the point of view of beam stability, the two important time scales are the magnetic field resistive decay time, and the inverse of the beam-plasma frequency. For threat-level beams, these times are on the order of nanoseconds. With respect to plasma formation and the development of σ, Dolique argues

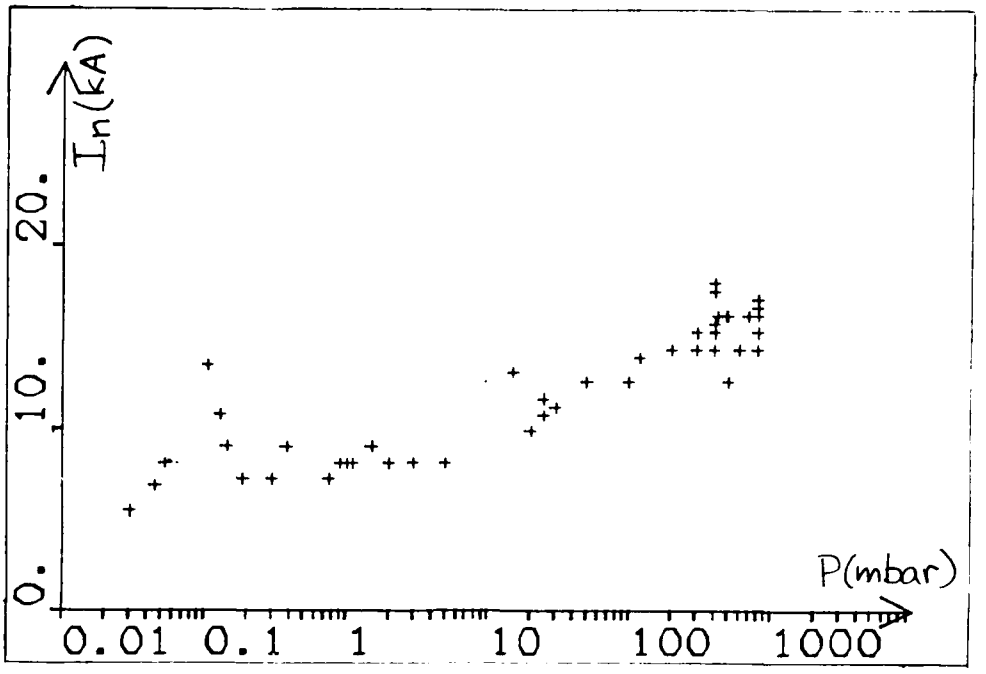

Figure 2. Net current versus background pressure.

that the experimental time scales for important atomic processes are comparable for the two types of beams: secondary electron creation and destruction times of 6 to 9 ns, characteristic impact-heating times of about 3 ns, and inelastic collisional cooling collisions in 1 to 2 ns. The idea, then, is to inject the EUPHROSYNE beam into the drift space and diagnose some aspect of plasma channel formation and conductivity development which could be predicted by code runs simulating the experimental conditions. One drawback of this and other low-energy beam experiments using pulse-line generators is that the length of the beam (about 45 m) is much greater than the length of the drift tube, so the field structure of an isolated beam propagating in the terrestrial atmosphere cannot be properly simulated. However, since all parts of the drift space have nearly simultaneous histories, diagnosis of the z-independent plasma is simplified.

It is planned to diagnose the plasma by analyzing the visible fluorescence spectrum excited in the nitrogen. This technique has the potential to determine the time development of the local plasma parameters, provided that the dependence of the fluorescence lines on the parameters is sufficiently well known. In preparation for the experiments, the electronic and vibrational structure of N_2 and N_2^+ were computed from the relativistic Bethe theory and rate equations were used to follow the time-dependent populations of the N_2 triplet and N_2^+ doublet states with emission in the visible. Line intensities were determined as a function of time for different N_2 and N_2^+ densities for comparison with experiment.

Data are being collected for the 3371- and 3914-angstrom lines using a prism spectrograph coupled to a pair of photomultipliers through optical fibers. The variation of plasma temperature can be unfolded from oscilloscope traces of the photomultiplier outputs and compared with model predictions. Agreement with theory in the 1-bar pressure range has been obtained.

One problem with the optical technique is that the calculated line intensities depend on the poorly understood secondary electron-velocity distribution. A direct measurement of the return current is more straightforward and, though no spatial resolution is provided by the technique, an immediate calculation of average conductivity from a magnetic diffusion equation can be obtained. This electrical technique has been successfully used by Greig and coworkers at NRL for a theory-experiment comparison under conditions similar to EUPHROSYNE. As indicated above, the analysis is simplified by the small

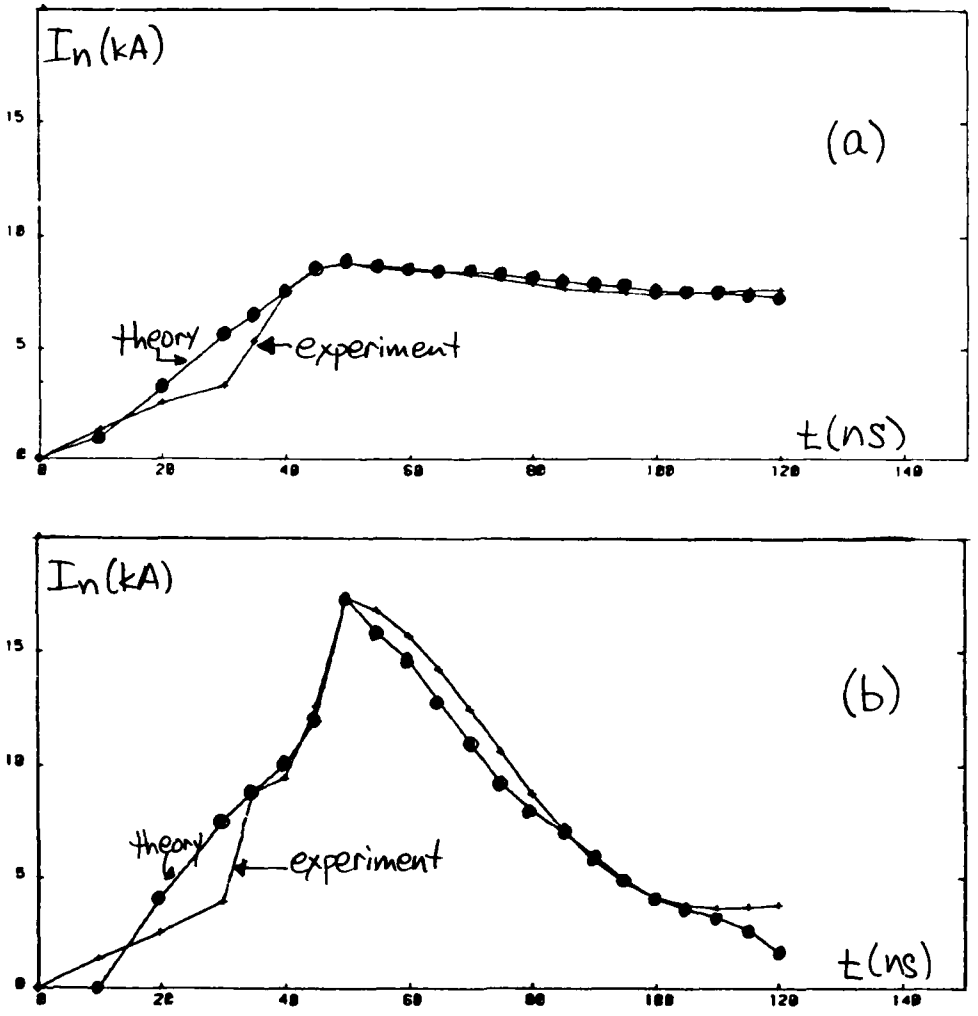

Figure 3. Net current histories for (a) 5-mbar and (b) 800-mbar background pressures.

ratio of drift length to beam length. Since the plasma temperature varies little along the short plasma channel, σ can be treated as a function of time only. One can then construct a circuit model for the resistive decay of the magnetic field

$$\frac{dI_n}{dt} = (R/L)(I_b - I_n), \qquad (1)$$

where I_n is the "net" current (the sum of the beam current I_b and plasma return current), R is a time-dependent resistance embodying the conductivity, and L is the channel inductance. If the currents are measured experimentally, $\sigma(t)$ can be determined from equation (1) and the channel geometry.

The beam current is given by the diode current, and Rogowski coils mounted in the gas measure the net current. In a vacuum or poorly conducting background, the net current is the beam current. In a highly conducting background, the net current is nearly zero since plasma electrons are free to move to neutralize the beam. In the experiments, the behavior in time can be complex as the atmosphere first breaks down and then heats during beam passage. The net current history was recorded by oscilloscope for background pressures ranging from 0.1 to 800 mbar and compared with that determined from equation (1) for specified $\sigma(t)$. Figure 2 summarizes EUPHROSYNE measurements of net current versus background pressure

Table 1

Conductivity Dependence on Pressure

p(mbar)	0.4	5	100	800
σ(mho-m^{-1})	150	470	53	28

at a time halfway through the beam pulse. The inferred conductivity dependence on pressure is summarized in Table 1 for the same time. The connection with PEGASE is made by using the code to calculate the time-dependent conductivity in equation (1). Experiment-computation comparisons for low and high atmospheric pressures are shown in Figure 3.

The French team has demonstrated the ability to model the complex interaction between an REB and the atmosphere and has begun low-voltage experiments to test their models. Though the work follows a line similar to Department of Defense-sponsored research in the US, it is the first indication by another NATO country of interest in REB directed-energy research.

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8/1/84

SCIENCE POLICY

SPAIN'S RESEARCH FUND SMALL BUT GROWING

by James W. Daniel, Scientific Director for Europe and the Middle East for the Office of Naval Research's London branch office. Dr. Daniel left on leave in September 1981 from the University of Texas, where he is Professor of Mathematics, of Computer Science, and of Education.

Funds for science in Spain are increasing significantly despite the economic difficulties that create strong competition for central government funds. Now government expenditure on R&D is only about 0.4 percent of Spain's gross national product (2.0 to 2.5 percent is typical for most European nations). The government's stated goal is to reach 0.8 percent by 1987.

The Comision Asesora de Investigacion Cientifica y Tecnica (CAICYT), which awards over half the government funds that are allocated in competitive research grants, has for 1984 received an increase of almost 25 percent; the Consejo Superior Investigaciones Cientificas (CSIC), which manages about 100 research institutes, has received a 36-percent boost. With inflation running at about 12 percent, these translate into real increases of 11 percent and 21 percent, respectively.

Central figures on R&D expenditures have only recently begun to be compiled, but officials in the Ministry of Education and Science estimate that in 1983 the government spent on R&D through its ministries some $360,000,000 (54 billion pesetas, where I assume 150 pesetas = $1.00). Another $100,000,000 was probably spent by government-controlled industry, and perhaps another $100,000,000 by private industry. Just over half the ministry-allocated funds came from the Ministry of Education and Science, with another 30 percent or so from the Ministry of Industry and Energy. Much of the government monies went into the universities and into existing CSIC institutes; the most flexible programs are the competitive grants awarded by the CAICYT.

Universities

The faculty in Spain's 30 public universities are in the first year of a major change. A new law, passed after many years of effort, took effect in August 1983; it provides for universities to appoint faculty members on the basis of their curriculum vitae, as judged by a committee of referees--much as in the US. This simple system replaces the *oposiciones*, a grueling system of seven elimination examinations and a 1-hour public lecture that was previously used to select faculty members. The exams were so broad as to

force most candidates to forego research and to concentrate on continual wide-ranging study in their early postdoctoral years; and critics charged that the public lecture received the highest marks not for scholarly content but for ending within 15 seconds of when scheduled. Spain's science-policy leaders hope that the new system will encourage and reward research among young scientists by awarding faculty posts to those with the strongest research records; they also hope similarly to attract back to Spain some of the many scientists who established successful careers elsewhere in Europe and in the Americas. The first appointments under the new system are being made in late spring and early summer of 1984, but it will be several years before the effects of the changed procedure can be evaluated. Meanwhile, the scattered groups of university-based high-quality researchers--in some areas of theoretical physics, biology, and materials science, for example--are optimistic.

CSIC

Created in 1939 to coordinate state research projects, the CSIC instead created its own network of independent research institutes; by 1983, some 2000 researchers were employed in about 150 institutes, one-third of which were operated jointly with universities, with the other 100 being CSIC-only operations. According to CSIC vice presidents Jesus Sebastian and Javier Lopez, perhaps 30 percent of these institutes are artificial or "ghosts": one- or two-person institutes with high overhead and low productivity. CSIC is seeking to eliminate such institutes; in recent months about 10 have been terminated and another three combined into a single more cost-efficient group.

The increased budget (now about $100,000,000) and savings from eliminating waste are in part being used to create new institutes in special areas. CSIC-university joint institutes were recently created in biochemistry, astronomy, economic geology, and pharmacology/toxicology; an independent CSIC institute on marine biology will soon be operating in newly built facilities north of Barcelona. And institutes in biotechnology and in new materials are under consideration. The joint institutes are usually more cost effective because university facilities can be used without constructing new buildings; the CSIC finds it difficult to create such institutes, however, if the subject area is interdisciplinary between traditional university departments (seen by the CSIC as sometimes inflexible and isolated).

Sebastian is heading CSIC's policy division as it plans for the next 3 years; the formal program should be adopted by September. At present he envisions concentrating 30 percent of the CSIC budget in major thrusts in five areas: new materials, aquaculture, microelectronics, biotechnology, and public transport.

CAICYT

Basic and applied research is supported through competitive grants from CAICYT, whose 1984 budget is about $54,000,000 compared with $43,300,000 in 1983; development work is generally supported by the Ministry of Industry and Energy, whose competitive-grant budget is less than one-third the size of CAICYT's. Support is channeled at CAICYT primarily through four types of programs: university or institute projects, industrial projects, special projects, and equipment acquisition.

University or institute projects accounted for about $13,500,000 of CAICYT's 1983 expenditures. These awards are to principal investigators at universities or CSIC (or other) institutes, typically in support of that investigator, a couple of postdoctoral colleagues, and a couple of lab assistants. The funds may be used for salaries of the colleagues and assistants, but not of the investigator. About half of the awards include an overhead allowance of at most 10 percent.

About $8,650,000 went for industrial projects in 1983. These awards actually are loans rather than grants, but they are interest free for 5 years. Each such award must at least be matched by the industrial recipient. CAICYT's leadership hopes to use this program in the future to stimulate cooperative research between universities and private enterprise--where, until now, there has been very little interaction.

The special-subjects program is new; about $6,700,000 in CAICYT's 1984 budget is slated for this area, with an equal amount expected from the various ministries. Efforts are of two types--R&D or mobilization. Funds for R&D efforts go to stimulate research on specifically defined problems in agro-energy, aquaculture, microelectronics, and public transportation in metropolitan areas. Funds for mobilization efforts go to develop the infrastructure and basic science necessary to launch national efforts in biotechnology and in high-energy physics: Spain has recently joined CERN, the Organization for European Nuclear Research.

In 1983 CAICYT spent about $6,700,000 through its equipment-acquisition program. Researchers also obtain equipment through CAICYT's university or institute projects, through grants from government ministries, and through agencies of Spain's autonomous districts (perhaps $13,500,000 in 1983).

CAICYT is also active in advising the government on international scientific affairs, including Spain's participation in international organizations, in multilateral agreements, and in bilateral agreements. Jose Antonio Muñoz-Delgado, the food technologist who directs CAICYT's international affairs division, thinks that the primary benefits to Spain from its past international activities have been the opportunities for Spanish scientists to obtain postdoctoral training in other countries. More recently, bilateral agreements with France and with the UK have also produced cooperative research projects between scientists from Spain and the other two nations. Spain's bilateral agreement with the US makes some $40,000,000 available in 1983 through 1987 for joint science, 15 percent for basic and 85 percent for applied work involving paired agencies of the two governments; Muñoz-Delgado hopes to see these funds used to support more cooperative research by equal partners than has occurred in the past.

3/12/84

UK PROBLEMS IN SCIENCE AND HIGHER EDUCATION

by D.L. Mott and F.L. Carovillano. Mrs. Mott is the Librarian for the Office of Naval Research, London. Dr. Carovillano formerly at ONR, London, is Professor of Physics at Boston College.

News items regarding the cuts in funding to higher education by the government in the UK are legion. (See "Hard Times for Higher Education in the UK," *ESN* 37-12:490 [1983].) The latest book on the subject is *The Attack on Higher Education*, by Maurice Kogan, Professor of Government and Social Administration at Brunel University. The book discusses the effects of the cuts by the current government on young people hoping to enter higher education, on teachers in universities and colleges who will lose their jobs, on diminishing research opportunities at universities, and on the expected closing of some universities and college departments. Kogan examines how the cuts were imposed and who bears the responsibility. Particularly important is his discussion of government savings versus the effect on the loss of opportunities for young people.

Science and university funding cutbacks already implemented or contemplated openly have affected attitudes and morale. In some fields, a brain-drain is again in effect, though not on the scale of the one that took place in the late fifties into the sixties. *The Sunday Times* (London, 5 February 1984) reported on the Science and Engineering Research Council's (SERC) concern with several problems, including the exodus of 100 biotechnologists in the past 5 years from the UK to North America, Australia, and the European continent; the planned closure of two of the Agricultural and Food Research Council's laboratories; the neglect of important areas of medium-term research, such as land use, geological surveying, and acid rain; the threat of the UK's possible withdrawal of some high-cost research areas, such as astronomy and high-energy physics; and other similar problems from budget cuts affecting science programs or university research.

The UK support of science is provided mainly through its five research councils, and overall funding in recent years has actually kept pace with inflation. Budget provisions have not kept pace, however, with the rising costs to do science, to upgrade or provide new equipment and facilities, and to participate in large projects (see *ESN* 38-4:213-215 [1984]). As a result, there has been a real squeeze on operating budgets requiring significant cutbacks. The research councils already find that an increasing number of top-rated research proposals, many by university scientists, cannot be funded because of inadequate resources.

In a white paper issued in February, the British government gave funding guidelines for the 1985 fiscal year for education and science. The government position is to continue to increment the budget for education and science to keep pace with inflation. The projected growth is from about $18.9 billion in 1984 to $19.9 billion in 1986. Research priorities will be implemented--certain areas will receive increased funding, and others will be cut or even discontinued. The SERC is expected to fare better than the other research councils and will also receive a special allocation for subscriptions to international programs or laboratories such as CERN,

the European high-energy-physics laboratory in Geneva.

Despite favored treatment, the ongoing budget exercises within SERC have produced surprises and concern in the scientific community. Major cutbacks are under consideration. For example, lower level budgetary guidelines have led to the suggested closing of the central laser research facility at the Rutherford Appleton Laboratory. The laser facility operates at an annual cost of about $3 million, is recognized for producing good science, and is used by more than 100 university researchers. The proposed closing of such an important facility indicates how thin the UK programming is and suggests that drastic measures are needed even for accomplishing modest budgetary cutbacks.

Another projected cutback is in the funding of space science and astronomy. Since there is widespread interest in fostering a UK-led space mission in the late eighties, this contemplated cut could have serious program implications.

These planned government actions are encountering serious opposition in the scientific community and from the research councils. For example, there is uniform opposition to starting new science programs without new money provided for that purpose in addition to an overall increase in the budget for science. And continued participation in international efforts with costly subscriptions, such as the $43 million annual fee for CERN, is an unpopular long-term practice.

Perhaps the most controversial recommendation made to the Government concerning SERC is that Herstmonceux Castle, which houses a large part of the Royal Greenwich Observatory (RGO), be sold and that the RGO be incorporated with some other body, such as the University of Edinburgh Observatory. This recommendation was made more than 6 months ago and is being met with stout resistance from the RGO and from the Royal Astronomical Society.

Cuts in university budgets are continuing into the third successive budget year. Operating at reduced budgets has affected virtually every phase of university operations: programs have been reduced or closed, teaching loads increased, research budgets reduced, and faculty positions eliminated. Concerns now relate to the universities' continued capability to do research and train future scientists. In related actions, university faculties are being threatened by attacks on the tenure system. Perhaps not surprisingly, in certain areas there is a documented decline of research productivity and diminished stature or reputation of groups or departments at government laboratories and universities.

The cuts to university budgets have diminished funds provided by the university to its faculty and staff for research facilities and basic equipment. Government research grants have been required to pick up these costs, thereby effectively increasing university overhead rates and decreasing the value of the grant.

Pursuing the doctorate has become less attractive to young scholars because of limited job opportunities and the limited opportunity to do research by those who have jobs in academia or at government laboratories. The likelihood of career and job security has been lessened because there are fewer entry-level positions and tighter tenure quotas. The promotion rate of tenured scientists has also slowed. University teaching loads have been increasing steadily. Low morale among university scientists seems to be commonplace.

The budget impact has produced widespread discontent among university faculty members. Promotion opportunities are jammed or have been reduced at every level. There are cases of faculty members retiring at ages 60 to 65 with the rank of lecturer. Even at the best universities, retirement is being used to reduce the size of the faculty by attrition.

A recent development reported in the 17 and 24 February 1984 issues of *The Times Higher Education Supplement* (London) may have dramatic repercussions. The Secretary of State for Education and Science, Sir Keith Joseph, has proposed a plan to abolish tenure for university teachers. (Such threats on tenure are also becoming all too common in the US, particularly in our public university sector, which corresponds better to the British system.) It would appear that Sir Keith's proposal is serious since the Committee of Vice Chancellors and Principals (CVCP) has proposed to support an alternate scheme of their own if his plan is dropped. The CVCP would endorse reforms to weaken tenure and significantly increase managerial powers in universities. Suggestions under consideration are hardly novel in the US and include increasing the probationary period for tenure from 3 to 5 years (it is 7 years at most US universities), reducing tenure quotas, extending short-term contracts, and reducing the retirement age to 60.

The CVCP has agreed to perform an efficiency study of university operations. The committee and Sir Keith's

office are discussing the scope of the study. The CVCP proposes to examine support services, administration, and purchasing but not academic matters such as teaching and research. But Sir Keith's office insists on a wider scope because questioning the allocation of resources must delve into academic operations.

There is little question that the current UK administration has favored science and recognizes its importance to the British economy. Although funding levels have been modest and less than needed, science has fared better than most areas of the economy in the recent actions or proposals for governmental funding. Leading economists and governmental advisors emphasize that the UK's continued capability to compete on the world market depends on its ability to keep abreast of developments and to maintain its position in high technology over the long term. The prerequisite is that the universities and government research laboratories provide a strong community of scientists active in basic research. In order to represent the needs of science at the highest levels, a recent recommendation has been to create a Minister of Science, analogous to the science advisor to the President in the US, to advise the prime minister directly and better cope with funding emergencies and priorities in science.

3/2/84

SPACE SCIENCE

FORMATION OF THE SOLAR SYSTEM

by R.L. Carovillano. Dr. Carovillano, formerly at ONR, London, is Professor of Physics at Boston College.

"Rotation in the Solar System" was the title of the latest of the distinguished series of discussion meetings held by The Royal Society of London. The meeting took place on 8 and 9 March 1984; about 75 scientists attended. The sessions of the meeting were entitled: "Introduction, Early Solar System, Rotation of Sun"; "Evolution of Rotation in the Earth-Moon System"; "Fluctuations of the Rotation in the Earth"; and "Rotation of Planets and Satellites."

The proceedings of the conference will be published by The Royal Society and will probably be available by 1986. This article reviews the presentations in the first session, dealing with the formation of the solar system.

M.M. Woolfson (The University, York, UK) spoke on the evolution of rotation during the early history of the solar system. The theory most in vogue today on solar or stellar formation is that stars and associated planets form from a solar nebula by a process of rapid condensation promoted by gravitational attraction in locations of mass concentrations. The main constraints on theories of star formation (or any other astrophysical process) are imposed by conservation principles required by the laws of motion.

The main problem of the star-formation theory as applied to the sun is that the sun today contains little of the total angular momentum of the solar system (namely, about 1 part in 180). Angular momentum conservation applied to the solar system imposes strong requirements--such as nonuniformities in the solar nebula in the distant past, mechanisms to account for angular momentum loss from the sun since the time of its formation, and severe expectations on the evolution of magnetic fields.

Woolfson discussed several alternative ideas of solar-system formation, but none would accommodate the dilemma of the small solar angular momentum. Other mechanisms were also discussed for the formation of a planet and its satellite system that gave more satisfactory results. In the past, Jeans and Alfvén have argued that the same formation mechanism should be used for the solar/planetary system as for the planet/satellite system. The preference for and use of separate mechanisms is becoming more common today.

More recent work in astrophysics has tried to include effects of the ubiquitous magnetic field. Unfortunately, the dynamical effects of magnetic fields on matter usually involve nonlinear processes that are difficult to describe mathematically or physically. On the other hand, the magnetic field effect on rotation, the balance of centrifugal and gravitational forces, and rotational braking times give greater flexibility to the theory of star formation. In any case, it is important to determine the degree to which the magnetic field can account for the difference between the small observed value of the solar system angular momentum and the large primeval value required by current theories.

Prof. L. Mestel (Astronomy Centre, University of Sussex, UK) spoke on the interaction of rotation and magnetic

field in the solar system. In the presence of a magnetic field, B, gravitational collapse will not occur for a mass less than the critical mass, Mc, defined by $Mc = F/3\sqrt{g}$. Here F is the magnetic flux threading the mass distributed over an average spherical radius R, $F = \pi R^2 B$, and g is the acceleration at R. As the nebular mass increases toward the critical mass, a large angular momentum loss is possible, and the centrifugal force becomes small compared to the gravitational attraction.

For a mass below the critical mass to undergo gravitational collapse, a mechanism must become operative to reduce the magnetic field. For example, processes such as radiation by Alfvén waves from the outer portions of the mass distribution or a topological change in magnetic field due to reconnection could reduce the magnetic flux. If the mass of the nebular gas exceeds the critical mass, then gravity becomes dominant and star formation can take place. A means to reduce the magnetic flux has not been quantified.

The sustained coupling of fields and motion from the early stages of star formation was contained in the so-called alpha-omega dynamo theory of E.N. Parker (University of Chicago). It is well known that a toroidal magnetic Bt is generated by the coupling of a poloidal magnetic field Bp to the angular velocity Ω. In Parker's scheme, Bt regenerates Bp through the Faraday induction equation, $\partial Bp/\partial t = \text{curl}\ (\alpha Bt)$. The induction requirement is essentially that Bt be a force-free magnetic field characterized by α so that αBt is the electromotive force (emf) parallel to the toroidal field. The emf is generated by the action of the Coriolis force on the convective motion of the matter. With convection and rotation, Parker's scheme closes the loop for dynamo fields, Bp⟷Bt.

In the discussion it was pointed out that observations of the solar wind have now been made *in situ* far from the sun. Although measurements indicate that the angular momentum loss of the sun due to the solar wind is only 0.3 to 0.5 of what was thought to apply, the difference is not large enough to affect current theories significantly.

Mestel commented on the 6-degree tilt between the angular velocity of the sun and the solar system. If the rotational velocity is not parallel to the magnetic field, a precessional torque would exist in the primeval system. If the outer portion of the cloud becomes magnetically detached (say, by reconnection), then the angular momentum of the core region can change (decrease for the sun) while the total angular momentum is conserved.

Prof. T. Gold (Center for Radiophysics and Space Research, Cornell University) developed the basis of his new theory on star formation in his talk on the early solar system and the rotation of the sun. Gold reviewed a number of features of the solar system that are difficult to explain in the framework of the conventional theory in which the formation of the sun by gravitational collapse is followed by the formation of the planets from a disk of gas spun out from the sun. Because the sun now has about 1000 times the mass and one-thousandth the angular momentum of the planets, the conventional theory requires that an extreme redistribution of angular momentum take place during the formation of the solar system. The problem is worsened by the recent evidence that Uranus and Neptune consist primarily of carbon, nitrogen, and oxygen. The loss or absence of hydrogen and helium from these planets would imply a further loss of angular momentum from the planetary system that would have had to originate from the early sun.

The small angular rotation rate and angular momentum of the sun after the generation of the planetary disk are the most difficult features to explain. And why does the spun-out planetary disk not have the same orientation as the sun? How could Uranus and Neptune be so far from the sun and not have condensed earlier? Why is there not a more common nuclear mix in the solar system? It would be difficult for magnetic coupling or other processes to account for these disparities. Gold opined that the solar system having evolved as an outward-spiraling system just does not add up.

Gold then proposed essentially the inverse process, where a contracting disk of interstellar material leads to the formation of both a central star and the protoplanetary disk. Inward spiraling would provide for a slow accretion rate, and the sun would form with a much smaller rotation rate (though still a bit too high, perhaps by a factor of 5, but more easily explained by a process such as magnetic coupling). The sun would form first, and longer times would be available for heterogeneous planetary formation at larger distances. The sun and the planets need not have the same composition.

The process of gravitational collapse can begin from an appropriate density fluctuation in a uniform molecular cloud. The density fluctuation, in stages, leads to heating, radiation,

and rapid energy loss. To do away with the density fluctuations, the system can form plane annular rings that would not necessarily be in the same plane. The inner rings could undergo rapid collapse and form the planets. The outer rings could last interminably and only occasionally undergo collapse. Gold suggested this as a possible mechanism for comet formation, i.e., as the origin of the Oort cloud.

In summary, the advantages of Gold's contracting-disk model of star formation are: it provides for nonuniformity in nuclear species, relative composition, and condensation rates; the formation process is slow and takes place in stages over long periods of time; the star does not form all at once, but slowly, and passes through several phases including an early degeneracy phase that sorts out star types.

3/22/84

NEWS & NOTES

FRENCH COMPANIES PURSUE BIOTECHNOLOGY RESEARCH

One year after the French government embarked on a concentrated program to mobilize resources in biotechnology, the Ministry of Research and Industry took a census of French companies that are conducting research in all aspects of this rapidly growing field.

The tabulation, which was published in the ministry's newsletter, shows that there is considerable overlapping of interests among the companies involved. In all, 31 companies have gotten started in France; their research interests are outlined in Table 1, below. It is obvious that the field of food and agricultural products leads the list of manufacturing interest, but not far behind is medical drug production.

Thomas C. Rozzell
3/27/84

THIRD WORLD CONGRESS FOR MICROCIRCULATION

The European Society for Microcirculation will sponsor and host the Third World Congress for Microcirculation at the John Radcliffe Hospital in Oxford, England, from 10 to 14 September 1984.

Based on the contributions received, symposia, workshops and plenary lectures are likely in the following topic areas: haemorheology; pharmacology of venules versus arterioles;

Table 1

French Companies and Their Biotechnological Activities

Subject	Drugs (Including Antibiotics, Immunology Derivatives, Hormones)	Reagents (Including Monoclone Antibodies and Enzyme Reagents)	Food and Agricultural Products (Including Seeds, Foods and Animal Feeds, Biopesticides)	Raw Materials Chemistry, Energy-Producing Compounds	Biodegradation and Antipollutants
Genetic engineering, microbiology	G3 Transgene Genetica Roussel-Uclaf Sanofi	Intergene	Transgene Roussel-Uclaf Sanofi BSN		
Cell fusion	Rhone-Poulenc	Immunotech Hybridolab	Clause SNEA		
Enzymes, enzyme engineering	Rhone-Poulenc		Roquette		
Fermentation cell cultures	Roussel-Uclaf Rhone-Poulenc Sanofi Merieux Inst. Synthelabo	Merieux Inst.	Lafarge-Copee Bel.Bongrain Sodima Rhone-Poulenc Protex Pernod-Ricard Air Liquide	EMC Rhone-Poulenc	
Instrumentation, development of extraction and purification processes	Rhone-Poulenc Biolafitte	Biosys	Biolafitte Nordon Seltric Technip (IFP) Speichim RSN		Degremont (Lyons Waters) General Water Company
Strain collections, data banks	Pasteur Institute		Museum		

diabetes mellitus, blood flow and endothelial cell metabolism; liver and spleen; pulmonary microcirculation; angiogenesis; transport through different endothelia; prostaglandins and leukotrienes; platelet storage and release; lymph production, protein clearance and lymph vessels; gastric mucosal microcirculation; oxygen free radicals; ultrastructure of vesicles; laser Doppler flowmetry; microcirculation of the heart; the interstitium; the role of serotonins in the microcirculation; skin microcirculation; dynamics of skin microcirculation in clinical medicine; tumor microcirculation, hyperthermia, and rheology; microcirculation and oxygen supply; biology of endothelial cells; metabolism and physiology; the eye; terminology of microcirculation; inhomogeneity of muscle blood supply.

A fairly extensive social program, centered around historic Oxford, is being planned. For more information, contact:

Secretariat
Third World Congress on Microcirculation
Department of Dermatology
Slade Hospital, Headington
Oxford OX3 7JH
ENGLAND

Before and after the congress, several satellite symposia will be held in England and The Netherlands. Titles, dates, and contacts follow.

1. Instrumentation and Techniques in Microcirculatory Research (1 through 6 September 1984). Contact:

Robert S. Reneman
P.O. Box 616, 6200 M.D.
Maastricht
THE NETHERLANDS

2. The Scientific Basis of the Care of the Critically Ill (5 through 8 September 1984). Contact:

R.A. Little
MRC Trauma Unit, Stopford Building
University of Manchester
Oxford Road, Manchester M13 9PL
ENGLAND

3. Carrier Mediated Transport of Solutes from Blood to Tissue (6 and 7 September 1984). Contact:

D.L. Yudilevich and G.E. Mann
Department of Physiology, Queen Elizabeth College
University of London, Campden Hill Road
London W8 7AH
ENGLAND

4. Regulation of Microcirculation in Muscles (15 September 1984). Contact:

Olga Hudlicka
Department of Physiology, The Medical School
University of Birmingham
Birmingham B15 2TJ
ENGLAND

5. International Society of Oxygen Transport to Tissue (26 through 30 August 1984). Contact:

F. Kreuzer,
Department of Physiology, Faculty of Medicine,
University of Nijmegen, Geert Grooteplein Noord 21a,
Nijmegen
THE NETHERLANDS

Thomas C. Rozzell
3/9/84

BIOMECHANICS AND BIOMATERIALS CONFERENCE

The European Society of Biomechanics will hold its fourth meeting from 24 through 26 September at Davos, Switzerland. This joint meeting with the European Society for Biomaterials will be conducted in two parts, with an educational program and a scientific program. The educational program will include the following pre-courses: Basic Mechanics of the Musculoskeletal System, Biomechanics Applied to Fracture Treatment, Biomechanics Applied to Prosthetic Joint Replacement, and Cardiovascular Mechanics and Ultrasonic Measurement.

The scientific program will cover all areas of basic and applied research in biomechanics and biomaterials, with three topic areas receiving special attention: Mechano-biology at Interfaces, Implant Related Bone Porosis, and Image Analysis.

Participants in the conference will have the opportunity to present their work in three categories: as an original scientific report given orally or by poster, as a scientific report with computer demonstration, or as a report of work in progress.

All accepted abstracts will be available at the meeting. A separate abstract of each paper will be published at full length in the *Journal of Biomechanics*. After the conference, selected contributions will be published

by Martinus Nijhoff Publisher B.V. as Volume 2 of the series "Biomechanics: Principles and Applications."

Additional information and registration materials may be obtained from:

Conference Secretariat
Laboratory for Experimental Surgery
Attn.: Miss Vreni Geret
CH-74796 Davos-Platz
SWITZERLAND
Phone: (083) 3 32 55

Thomas C. Rozzell
3/9/84

EUROPEAN GEOPHYSICAL SOCIETY ANNUAL MEETING

The annual meeting of the European Geophysical Society (EGS) will be held at the Université Catholique de Louvain-la-Neuve, Belgium, from 30 July through 3 August 1984. EGS is a relatively new society, founded in 1971, and is considered the European counterpart to the American Geophysical Union. The EGS has three main sections that cover broad areas of geophysics: I, Solid Earth and Planets; II, Hydrospheres and Atmospheres; III, Upper Atmospheres, Ionospheres, Magnetospheres, and the Interplanetary Medium. Each section will sponsor symposia and workshops at the annual meeting.

Section I will have the following symposia: Structures of Pre-alpine Orogenics, Future Planetary Missions, Convection Phenomena, and Experiments in Solid State Physics Relevant to Lithospheric Dynamics. Workshops will be on: Paleomagnetism, Age Dating and Sedimentology of Young Sediments, and Aspects of the Energy Balance at the Surface of the Earth.

Section II symposia are: Physical Processes in Atmospheres, Oceans, Hydrospheres and Soils, as Revealed by Remote Sensing; Analysis of Non-linear Transport Process in Soils; Turbulence in Rotating Fluids; Long-Lived Eddies in Oceans and Atmospheres; Topics in Climate; and Modelling of Mesoscale Processes in Air-Sea Interaction.

Section III symposia are: Thermosphere/Ionosphere Coupling at High Latitudes and Possible Solar Winds/Magnetosphere Influence, First Results From European Geophysics and Solar Experiments on Spacelab, and Solar Geophysical Indices Revisited. A workshop will be held on magnetospheric effects on seismic activity.

There will also be open sessions in each section for contributed papers. Three EGS Society Lectures are planned: P. Tappmier (Paris), "Space Tectonics of Asia"; M. Melchior (Louvain-la-Neuve, Brussels), "The Role of Tides in Earth Sciences"; and M. Nicolet (Institute of Space Aeronomy, Brussels), "Solar Activity, Variations of UV and X-ray Fluxes."

For information on the meeting, contact:

Prof. A. Berger UCL-IAG
Chemin Cyclotron 2
1348 Louvain-le-Neuve,
BELGIUM

R.L. Carovillano
3/12/84

CONFERENCE ON SOLAR SYSTEM ABUNDANCES

The international conference "Abundance Ratios in the Solar System" will be held from 19 through 22 June 1984 in Paris, France. The conference is organized by the French space agency, Centre National d'Études Spatiales, and is interdisciplinary in scope. Sessions and discussions are intended to give astronomers, astrophysicists, and planetologists the opportunity to compare results, approaches, and interpretations. The program will include invited papers and approved contributed papers selected for either an oral or poster presentation. The official languages of the conference are French and English, with simultaneous translation of oral presentations.

The following sessions are planned: (1) Isotope Abundance Measurements in Extraterrestrial Matter, (2) Abundance Ratios in the Sun, Stars, and Comets, and (3) Implications on Cosmogony, Cosmology, and Galactic Evolution.

Session 1 will emphasize results from laboratory analysis of extraterrestrial matter such as meteorites and lunar samples. Improved laboratory techniques in recent years have greatly increased the capability to determine the isotopic content of such matter and to perform accurate dating analysis on each species present.

The empirical evidence on abundance ratios for session 2 derives from spectroscopy, primarily in the visible and infrared, and mass spectroscopy on grains exposed to the solar wind and planetary atmospheres. Observations of isotopic ratios involving H, He, C, N,

O, Ar and other light nuclei will be featured.

The constraints of observed isotopic abundances upon interpretations and theory will be the theme of session 3. Differences between solar system ratios and composition results for other galaxies will also be discussed.

Plans are to publish proceedings of the conference. Inquiries may be addressed to:

Centre National D'Études Spatiales
Départment des Affaires
Universitaires
18, Avenue Edouard-Belin
31055 Toulouse Cedex
FRANCE
Telex: 531081 F

R.L. Carovillano
3/13/84

PAPERS FROM THE 1983 NORDIC ASTRONOMY MEETING

The 1983 Nordic Astronomy Meeting was held from 15 through 17 August in Oslo. Sessions dealt with stellar atmospheres and activity, modern instrumentation, and the plan for a Nordic optical telescope. Papers presented at the meeting are now available in three reports: Report No. 58, *Astronomy From Space--Past and Future*, by Olav Kjeldseth Moe; Report No. 59, *Papers Presented at Nordic Astronomy Meeting in Oslo, August 15-16, 1983*, edited by Oivind Hauge; Report No. 60, *Papers Presented at Nordic Astronomy Meeting in Oslo, August 17, 1983, Discussions on Nordic Optical Telescope*, edited by Jan-Erik Solheim. Inquiries may be addressed to:

Institute of Theoretical
Astrophysics
University of Oslo
P.O. Box 1029
Blindern, Oslo 3
NORWAY

R.L. Carovillano
3/14/84

PROCEEDINGS OF THE 1983 INTERNATIONAL CONFERENCE ON FOURIER TRANSFORM SPECTROSCOPY

The 1983 International Conference on Fourier Transform Spectroscopy was held at Durham University, England, from 5 through 9 September 1983. The conference received wide sponsorship, including direct support from the Office of Naval Research, London; the US Air Force Geophysics Laboratory and the European Office of Aerospace Research and Development; and the European Research Office of the US Army, located in London. Proceedings of the conference appear in the May 1984 issue of the journal *Infrared Physics*, published by Pergamon Press (Oxford OX3 0BW, England, and Elmford, NY 10523). Normal refereeing procedures were used for papers that will appear in the publication.

The conference included a large number of invited and contributed papers. Invited presentations were given by:

P.R. Griffiths (University of California, Riverside): Specimen Sampling Techniques.
D.B. Chase (Du Pont, Wilmington, DE): Surface Studies.
D.W. Vidrine (Nicolet Instrument Corporation): Chromotography FTS.
H.A. Willis, J.M. Chalmers, and M.W. MacKenzie (Infrared and Raman Discussion Group): Industrial Applications of FTIR Spectroscopy.
A.E. Costley (NPL, Teddington): The Study of Transient Sources Using Fourier Transform Spectroscopy.
A.J. Steed (Utah State University): Time Resolved Studies With Field-Widened Instruments.
H.H. Mantsch (NRC, Ottawa): Biological Applications of Fourier Transform Infrared Spectroscopy.
K. Holland-Moritz (Institute of Physical Chemistry, Cologne): FT-IR Spectroscopic Studies on Fast Time Dependent Phenomena in Polymers.
J.C. Mather (Goddard Space Flight Center, MD): Cryogenic Fourier Spectrometers.
W.D. Duncan (Royal Observatory, Edinburgh): Absolute Radiometry With Fourier Transform Spectrometers.
J.R. Birch (NPL, Teddington): Dispersive Fourier Transform Spectromtry.
G. Guelachvili (University of Paris, Orsay): Fourier Transform Spectroscopy and Molecular Studies.
I.M. Mills (University of Reading): The Interpretation of High-Resolution FTIR Spectra.
B. Carli (IROE, Florence): Far Infrared High Resolution FT Spectroscopy for Stratospheric Studies.
L. Delbouille (University of Liège, Belgium): Medium Infrared Solar and Atmospheric Studies.
J. Connes (Circe, Orsay): Resolution Enhancement by Numerical Methods.
T. Hirschfeld (Lawrence Livermore National Laboratory, CA): The FTIR Advantage Produced by Throughput Loss.

The program included about 108 contributed papers in six sessions: Surface Layers, Matrices, and Microsampling; Industrial Applications; Condensed State; Studies on Large Molecules; High Resolution Spectroscopy and Numerical Aspects; and Instrumentation.

R.L. Carovillano
3/8/84

NEW GEOLOGY JOURNAL

Marine and Petroleum Geology, a new European-based quarterly journal, began publication in February 1984. The journal is published jointly by Butterworth Scientific Ltd. and the UK Geological Society. The editor-in-chief is Dr. D.G. Roberts of British Petroleum in London, and the North American regional editor is Dr. D. Scholl of the US Geological Survey, Menlo Park, CA.

According to the editor, *Marine and Petroleum Geology* was launched to provide a new international forum for the exchange of multidisciplinary data, techniques and concepts relevant to all stages of exploration and to geologists, geophysicists, and geochemists.

The first issue of the journal includes four research papers that average about 12 pages each, followed by 40 pages of recent citations, patent reports, and a calendar of meetings. One of the papers (by Roberts and Kidd) includes some excellent sonographs of the Iberian continental margin. The researchers used the UK's side-scan sonar GLORIA.

The annual subscription is £120 ($180). For subscription information write to Quadrant Subscriptions Services Ltd., Oakfield House, Perrymount Road, Haywards Heath, Sussex RH163DH, England.

Robert Dolan
3/12/84

UK MOD CONSOLIDATES RESEARCH ORGANIZATIONS

The UK is going to combine six of its research establishments to form two, according to *The Times* (London, 3 April 1984).

The Admiralty Research Establishment will be made up of three organizations concerned with naval research: the Admiralty Marine Technology Establishment, the Admiralty Surface Weapons Establishment, and the Admiralty Underwater Weapons Establishment.

The present Royal Armament Research and Development Establishment will take in the Military Vehicles Engineering Establishment and part of the Propellants, Explosives and Rocket Motor Establishment.

Larry E. Shaffer
4/4/84

ONRL STAFF CHANGES

This month we welcome two new staff members:

Dr. Patrick Leehey comes from the Department of Applied Mechanics at the Massachusetts Institute of Technology; his specialties are naval architecture and applied mathematics.

Dr. Norman Ness comes from the Laboratory for Extraterrestrial Physics, Goddard Space Flight Center, NASA; his specialty is space physics.

ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

Note: A conference that appeared on this list in the April and May *ESN*s has not been approved for support by ONR, London: Third International Symposium on Halide Glasses, Université de Rennes, Rennes Cedex, France. The symposium will be held 24-28 June 1985--not 24-28 June 1984. *ESN* regrets the error.

International Conference on Laser Processing and Diagnostics--Applications in Electronic Materials, Linz, Austria, 15-19 July 1984.

Tenth General Assembly of the European Geophysical Society, Louvain-la-Neuve, Belgium, 30 July - 4 August 1984.

Fifth International Symposium on Gasflow and Chemical Lasers, Oxford, UK, 20-24 August 1984.

Fatigue '84, Birmingham, UK, 3-7 September 1984.

International Conference on Digital Signal Processing, Florence, Italy, 4-8 September 1984.

Surface Modification of Metals by Ion Beams, University of Heidelberg, Federal Republic of Germany, 17-21 September 1984.

Ninth European Specialist Workshop on Active Microwave Semiconductor Devices, Veldhoven, The Netherlands, 10-12 October 1984.

FEBRUARY/MARCH MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during February and March. The *MAS Bulletin* is an account of naval developments in European research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

MASB Number	Title
8-84	A Vibrating-Vane (Flex-Vane) Flowmeter Developed to Accurately Measure Fuel Flow Rates
9-84	Laser Color Filmwriter
10-84	Corrosion Resistant Organic Coatings for Studbolts
11-84	New Developments at Marconi Avionics in the UK
12-84	Gen-Coat Plus: Protective Coating Prevents Corrosion of Reinforced Concrete
13-84	The 26th Israel Annual Conference on Aviation and Astronautics (IACAA)
14-84	Soviet Emphasis on Mine Warfare
15-84	The International Symposium on Differential Game Applications (ISODGA)-- With an Emphasis on Air-to-Air Combat Analysis
16-84	A Millimeter-Wave Measurement System Designed to Monitor Peak Internal Pressures in Aircraft Tires
17-84	Fleetfusion--A Spiral Metal Fusion Process for Repairing/Enhancing Shipboard Engineering Components
18-84	Tromso Telemetry Station Covers Arctic Regions
19-84	Update on UK Royal Navy Environmental Support Programs
20-84	Notes on Remote Sensing in Europe
21-84	Oil Trawl for Bulk Oil Slick Cleanup
22-84	The British Press Describes the Performance of Arapaho Aboard RAF Reliant
23-84	First Quarterly Index 1984

EUROPEAN VISITORS TO THE US SPONSORED BY ONR, LONDON

Visitor	Areas of Interest	Organizations to be Visited	Want Information? Contact at ONRL
Dr. C.A. Brookes Dept. of Engr. Science University of Exeter North Park Road Exeter, Devon, EX4 4QF	Engineering Science/ Hardness Testing	Naval Research Laboratory NSWC Silver Spring, MD (9-20 July 84)	James W. Daniel
Prof. Brian Ridley Department of Physics University of Essex United Kingdom	Semiconductors	ONR HQ NRL (July 1984)	James W. Daniel
Prof. David Tabor Univ. of Cambridge Cavendish Laboratory Madingley Road Cambridge CB3 0HE	Physics/Friction & Wear	ONR HQ Naval Research Laboratory NSWC (9-20 July 84)	James W. Daniel

SCIENCE NEWSBRIEF FOR APRIL

The following issue of *Science Newsbrief* was published by the ONR, London, Scientific Liaison Division during April. *Science Newsbrief* provides concise accounts of scientific developments or science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

Science Newsbrief Number	Title
2-2-84	UK Government Rejects Increased Research Funding--May Withdraw From CERN, by James W. Daniel.

ONRL REPORTS

To request reports, check the boxes on the self-addressed mailer and return it to ONR, London.

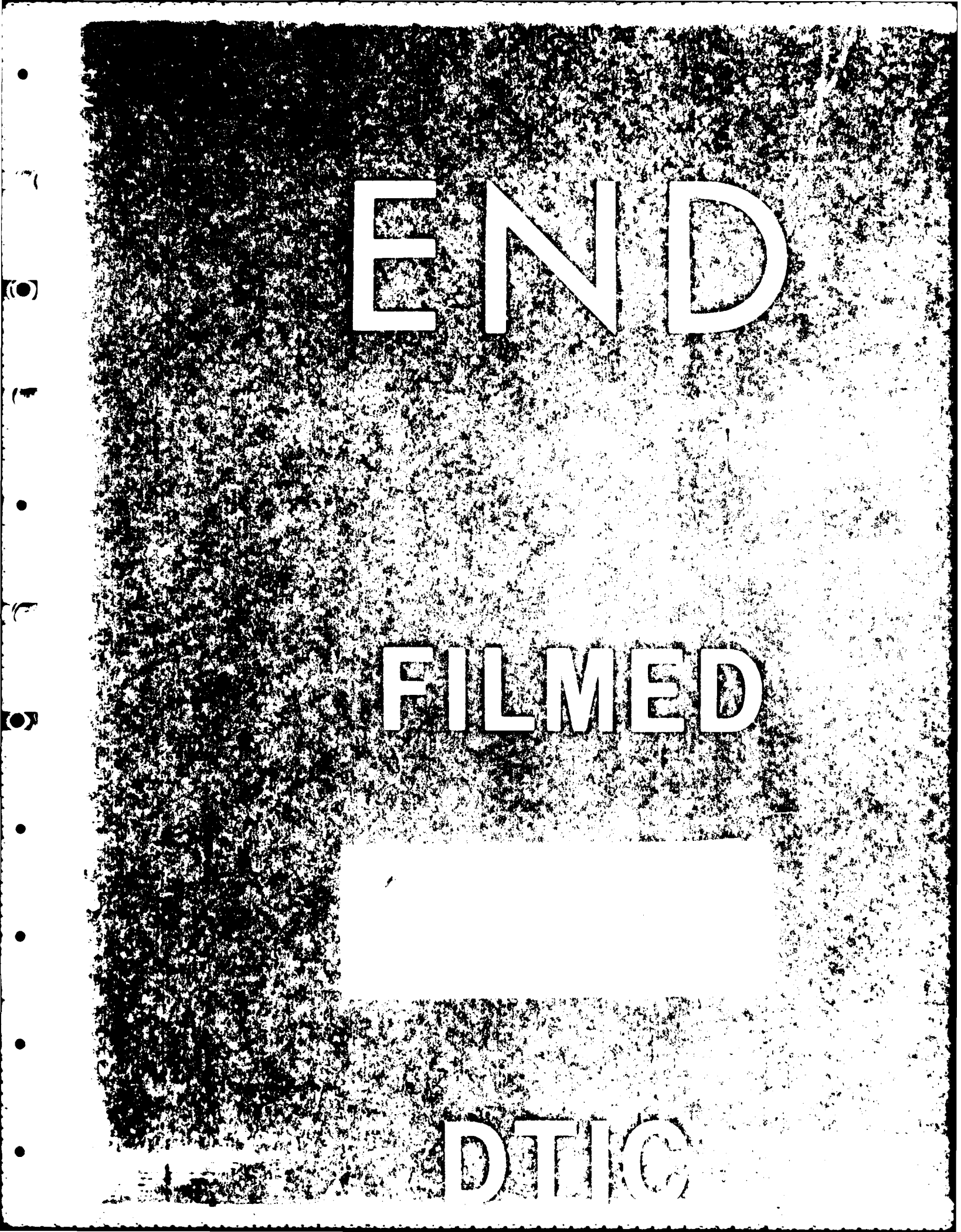
C-1-84: *Sixth International Conference on Computing Methods in Applied Sciences and Engineering*, by J.F. Blackburn. The conference, held in December 1983, covered the following areas: structural and fluid mechanics, nonlinear analysis, oil reservoir simulations, compressible fluids, numerical algebra and software, semiconductors and hysteresis, multigrid methods, and parallel computing.

R-2-84: *Science in the European Economic Community: A Self-Assessment and a Detailed Plan of Action*, by James W. Daniel. This report summarizes the European Economic Community's (EEC's) new scientific policy, provides the EEC Commission's assessment of the Community's international position in science policy, and presents the detailed scientific and technological goals of a program for coordinating and planning future policy.

R-3-84: *Statistics and Operations Research in Europe--1983: Summary Report*, by D.R. Barr. This report examines work in statistics, operations research, and closely related fields in Europe. The report updates *Statistics, Operations Research, and Management Science in Europe--1982: Summary Report*, R-2-83 (US Office of Naval Research, London, 1983).

R-4-84: *A Survey of European Robotics Research*, by Scott Harmon. This report describes the results of a 1981 survey to gather information about European robotics research that might be tailored to meet the US Navy's needs. The objectives of the study were: (1) to identify key research organizations and scientists, and (2) to determine the nature of the research and technology. The survey covered Belgium, France, the UK, Italy, Switzerland, and the Federal Republic of Germany.

R-5-84: *European Research on Polymers and Composites*, by R.W. Armstrong and Vivian T. Stannett. This report discusses the strategies and funding for research on polymers and composites in the UK, the Federal Republic of Germany, and France.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